Counterfeit Examples

Electronic Components

These examples illustrate and supplement the inspection and test criteria in

Components Technology Institute Inc.

Counterfeit Components Avoidance Program

CCAP-101 Certified *

Appendix A-6, Rev. E

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Counterfeit Examples

IC Markings

IC markings can be split into four parts:

1 The **prefix** identifies the manufacturer - usually by a one to three letter code. However, a manufacturer may have several prefixes.

2 The **device code** identifies the specific IC type.

3 The **suffix** indicates package type and temperature range. Each manufacturer has its own set of suffices, subject to frequent modification. There are four common temperature ranges for these applications:

-65°C to +150°C Aerospace
-55°C to +125°C Military
-25°C to +85°C Industrial
0°C to +70°C Commercial

4 The **date code** is normally a four digit code - the first two digits indicate the year, and the last two the week number. A date code of 9921 for example would indicate the date of manufacture as week 21 of 1999. Some devices, however, are date coded in a form known only to the manufacturer.

Counterfeit Examples

Marking Methods

Common marking techniques are:
- ink marking device,
- laser machining.

Ink marking can be carried out by:
- stamping,
- screen printing
- transfer printing – poor quality
- pad printing – an advancement
- ink jet printing – fast and flexible

Laser marking:
- CO_2 or YAG laser
- Quick and no post cure
- Very flexible

Counterfeit Examples

Incoming

- Check the shipping document information against the PO. Ensure that part numbers and quantities agree, verify that date code and lot numbers match the outside markings.
- Check the barcode scan matches exactly the information on the label.
- Check the packaging. If not new & similar to OCM - suspect counterfeit.
- Country of origin, does this match where OCM has plants?
- Look for errors in spelling, parts count, shippers, etc.
- Record all observations on Inspection Form.

Counterfeit Examples

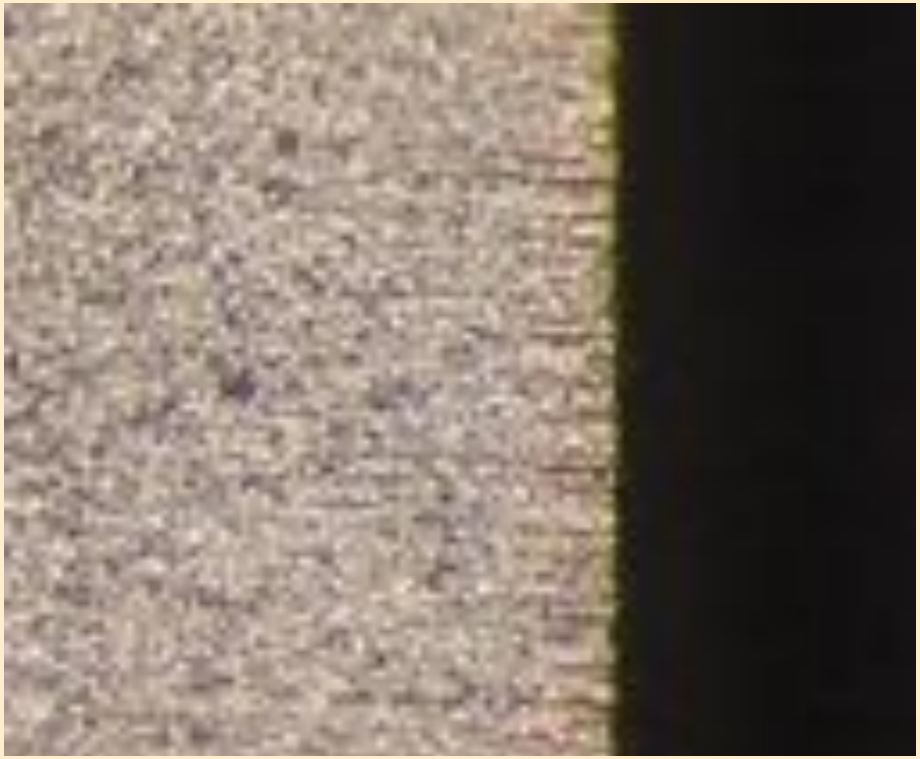
INDICATIONS OF PREVIOUS USE OR TAMPERING

- Leads/pins bent, scratched, broken or missing
- Oxidation, discoloration, corrosion.
- Texture on top and bottom and sidewall surfaces
- Dissimilar Leads/pins ends coated with solder
- Indications of marking alteration such as: Blacktopping, sanding, remarking or clear coating to protect remarking.
- Packaging: Do date code & lot number match documents?
- Do trays conform to OCM typical?
- Any indications the components have been repackaged since leaving the OCM?
- Any of the above characteristics create suspicion of counterfeits, when seen, look much closer

Counterfeit Examples

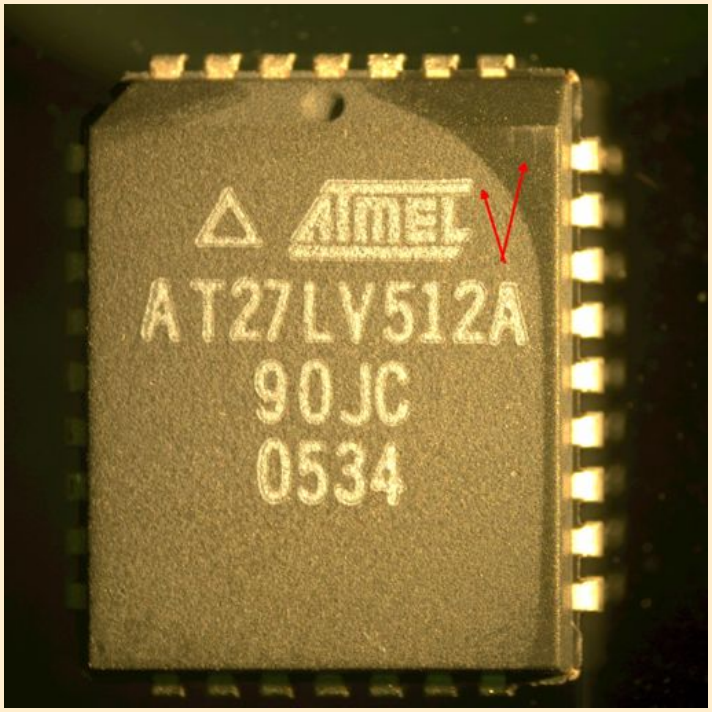
Sanding

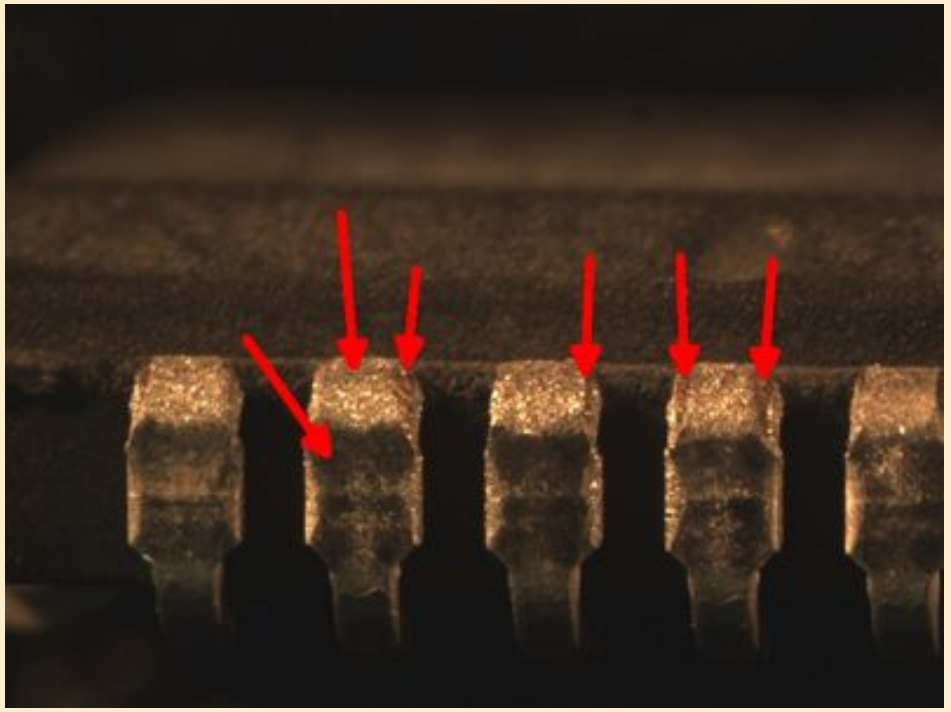
Metal lid parts, sanding marks may also be visible at the edge of the lid.



Counterfeit Examples

Sand Blasting

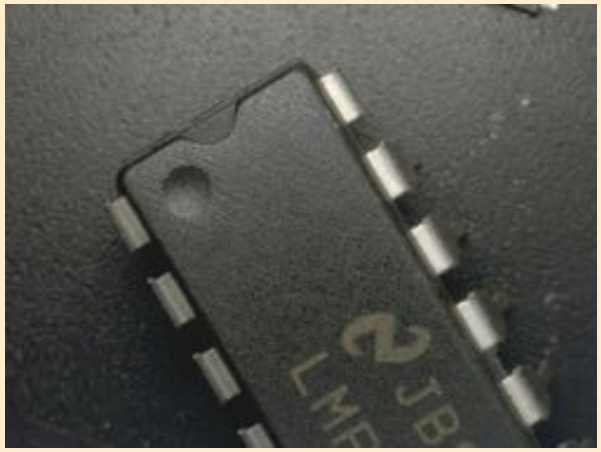




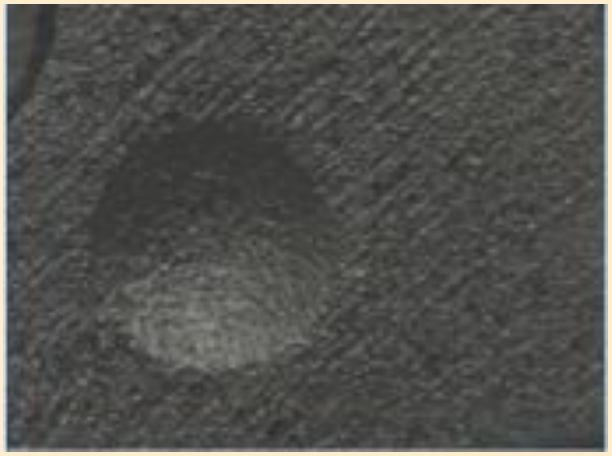
- Sand blasting is one technique for removing markings.
- This technique leaves very distinct signs plus the leads were not protected and show pitting.
- Sand blasting can also build up static charges that cause ESD to die.

Counterfeit Examples

More examples of blacktopping



- See the sanding marks.
- Obvious blacktopping.



- See coating and sanding marks.
- Pin 1 mark is too shallow and bottom same texture as top.
- Needs scrape & HST.

- This is not how bottom of mold mark usually look.
- Looks like top coating material ran to bottom or a mold defect.
- Requires more analysis.

Counterfeit Examples

CF Suspect

- Unusual appearance for encapsulation mold.
- However the top and bottom could have different surfaces.
- Edge appears to have a dull caulked bulge at meeting surfaces.
- However lead frame support shows copper as it should.
- Aggressive pursuit is required with Scrape & HST.

Counterfeit Examples

Almost certainly blacktopped.

See fake pin 1 ident.

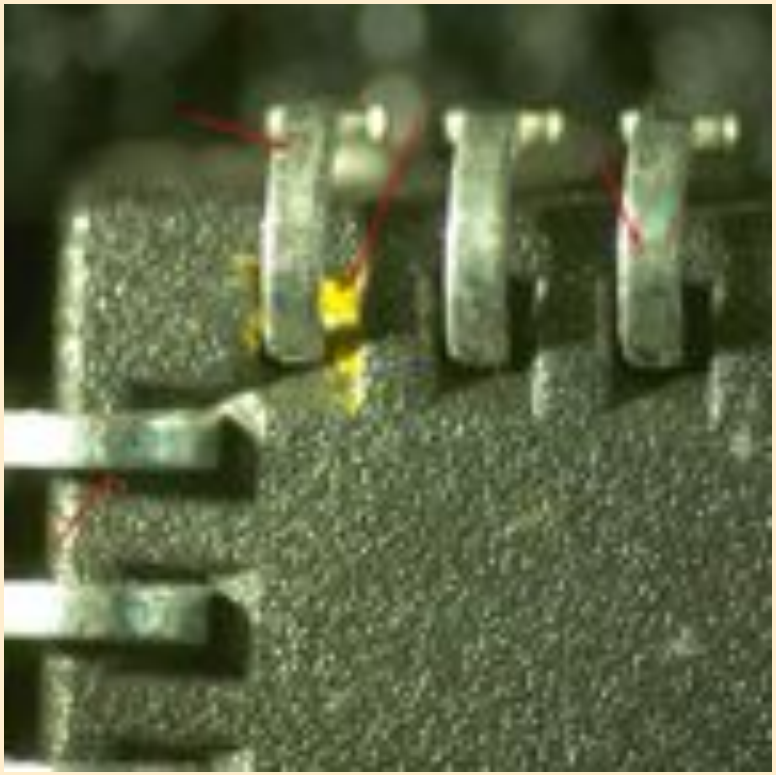
Needs scrape test and HST to verify.

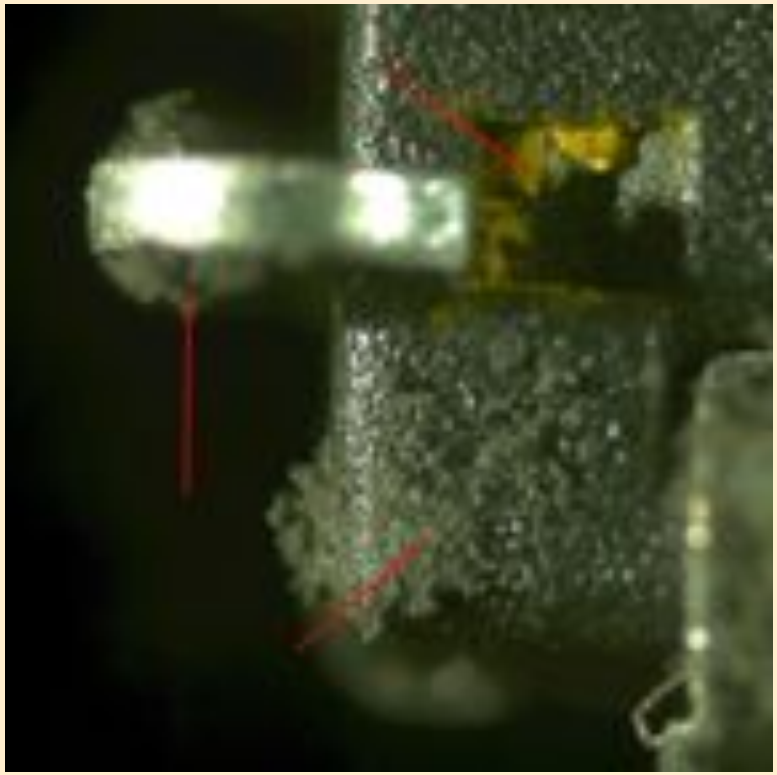
No reason to miss these sloppy jobs.

Counterfeit Examples

- Important to compare top and bottom in one photo.
- Surfaces show difference in texture.
- This demands aggressive search for top coating, scrape & HST.

Counterfeit Examples





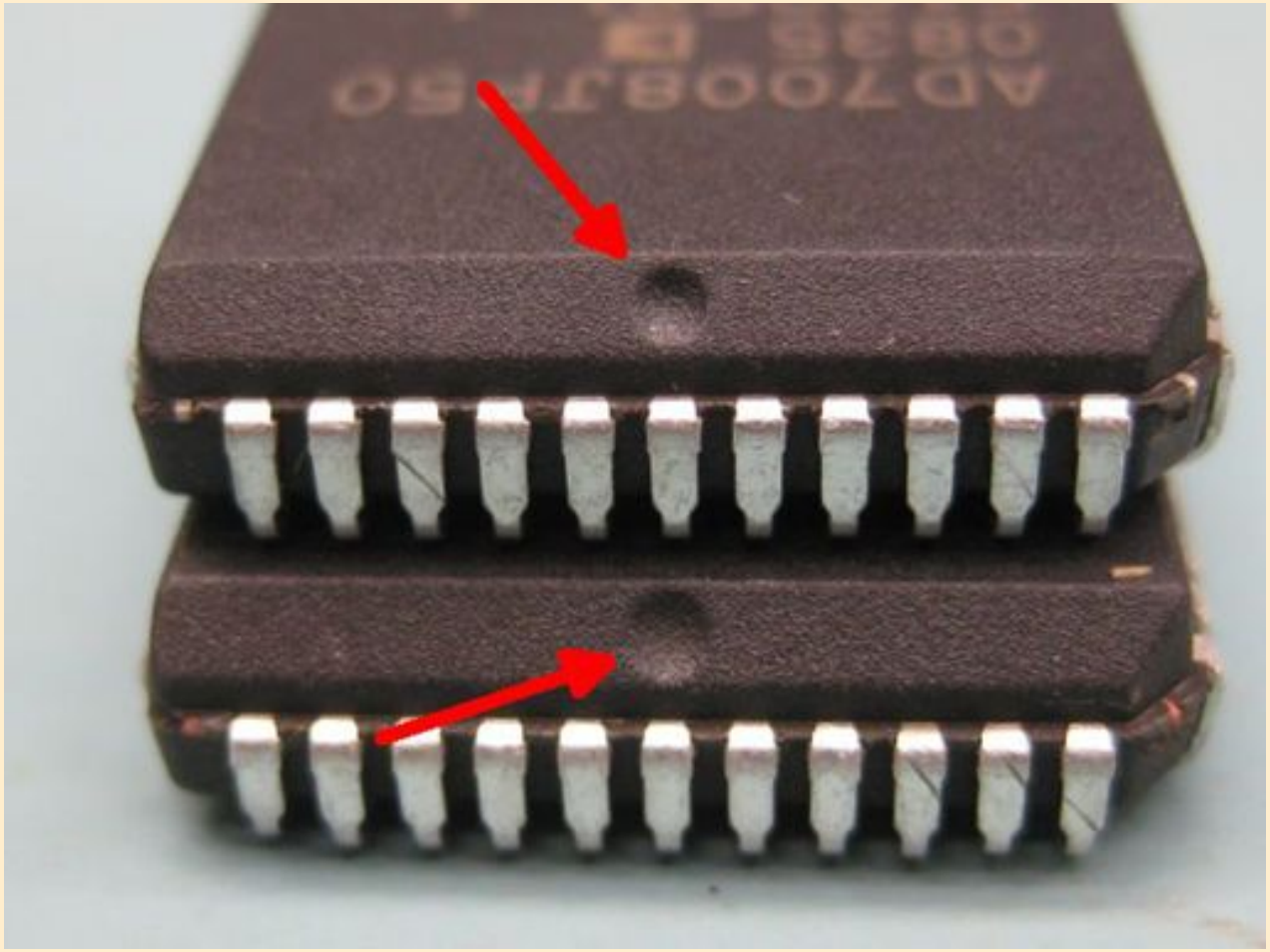
Highly suspect as reclaims.

Signs of solder touchup and flux residue.

Do not leave the OCM factory looking this way.

Counterfeit Examples

Mold mark differences are very suspicious.



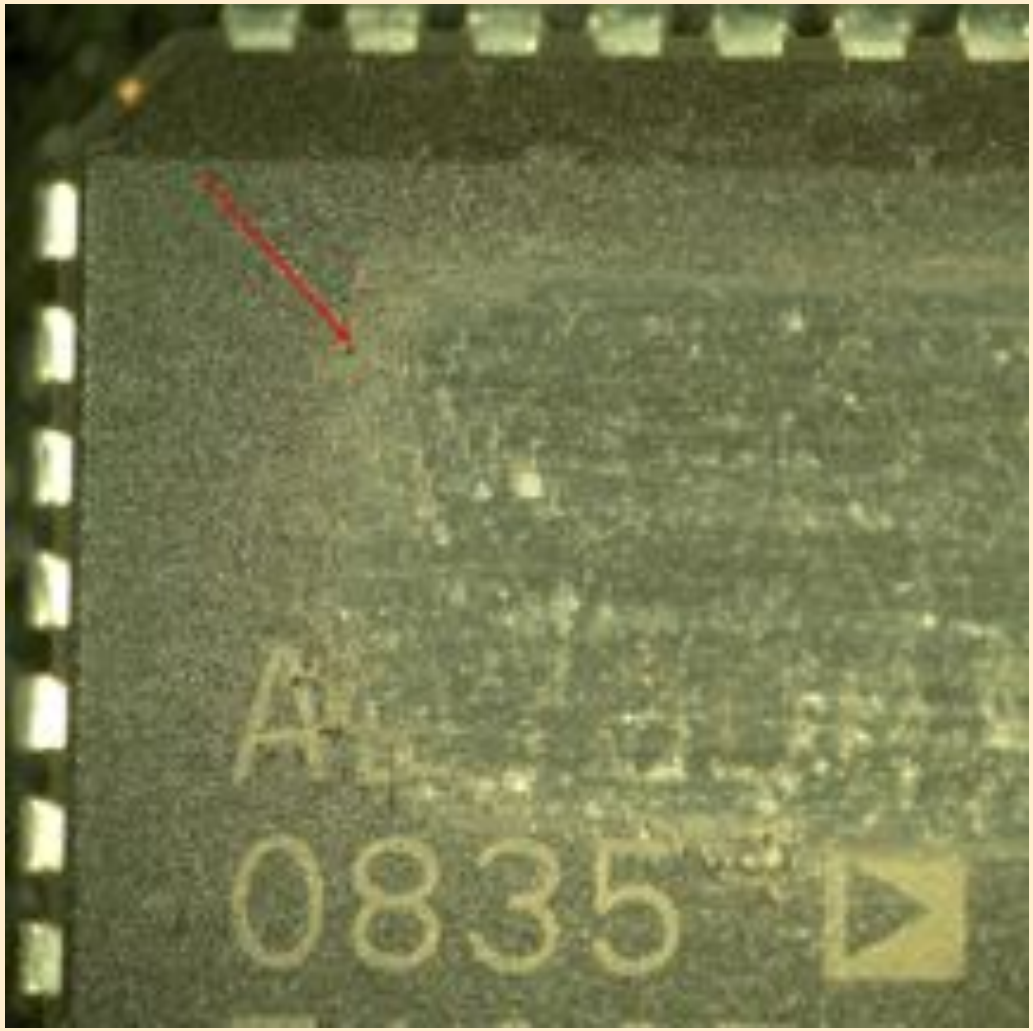
Counterfeit Examples

X-ACTO knife test

Scrape Test works on most coatings.

Quicker and easier that HST.

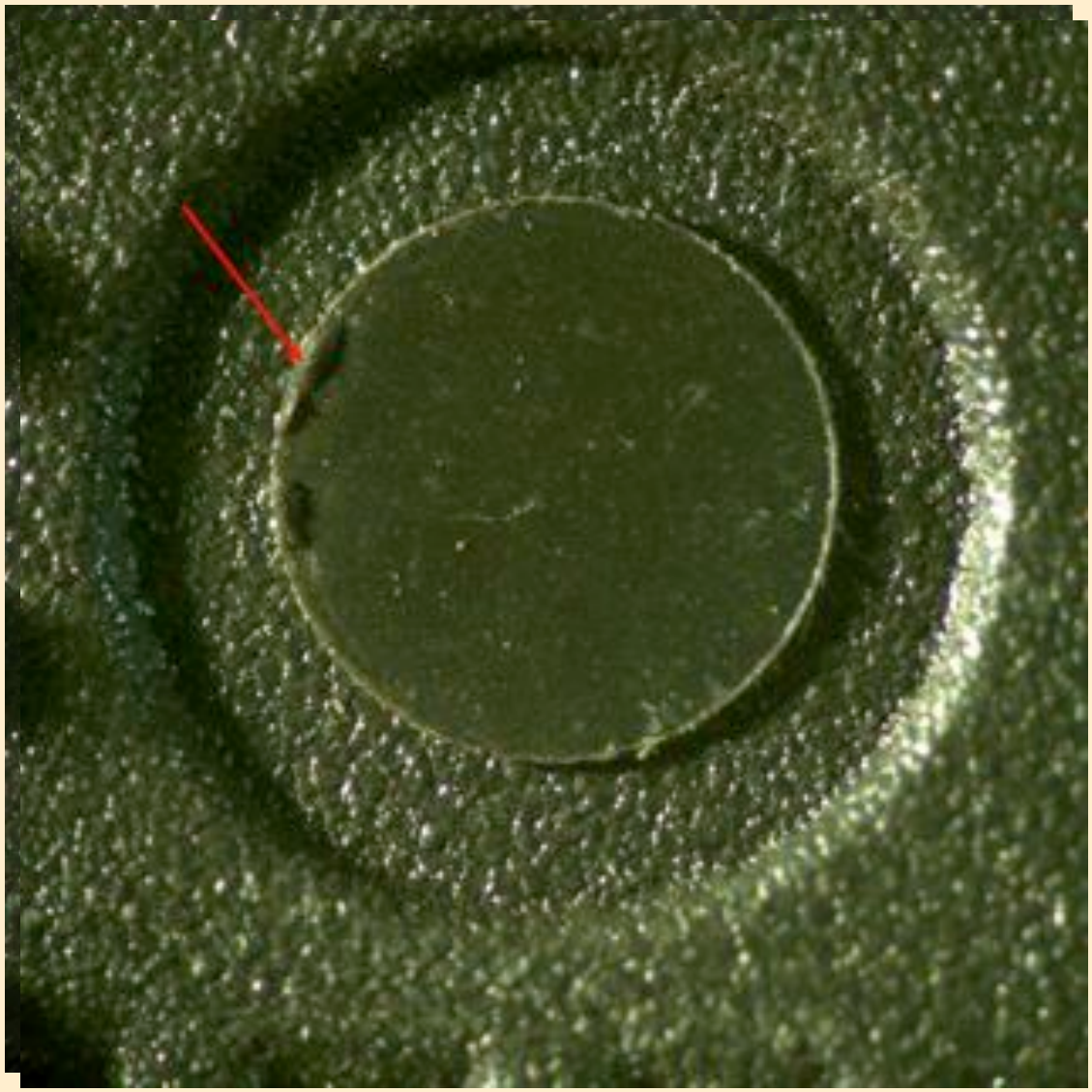
Takes practice to apply right pressure and blade angle.



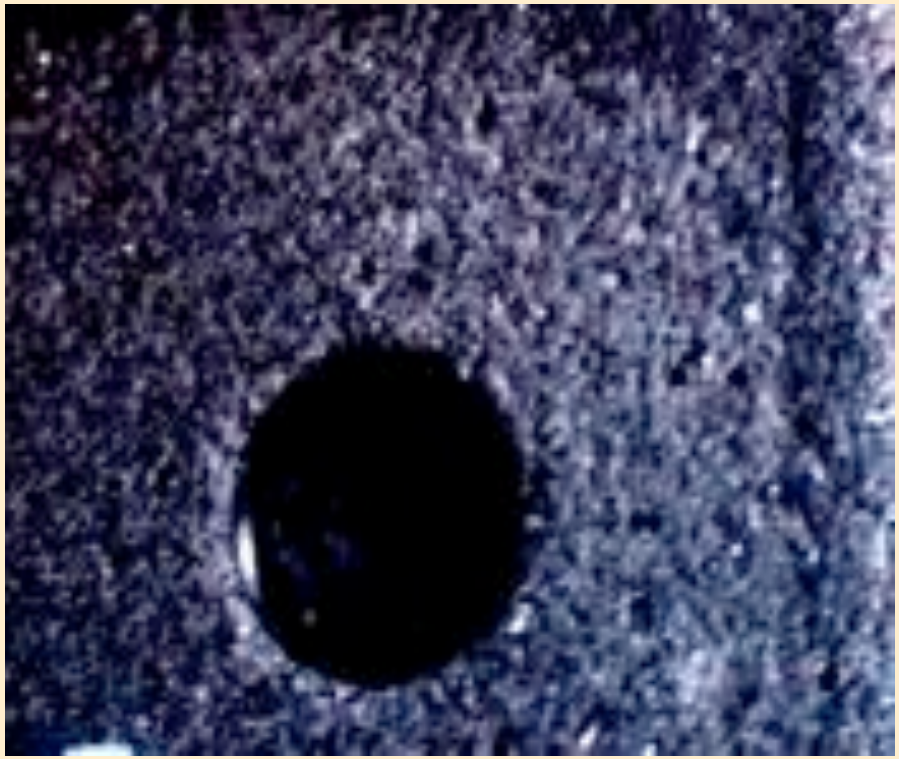
Counterfeit Examples

Attempt to duplicate the mold mark.

Smaller smooth circle added to hide the black topping.

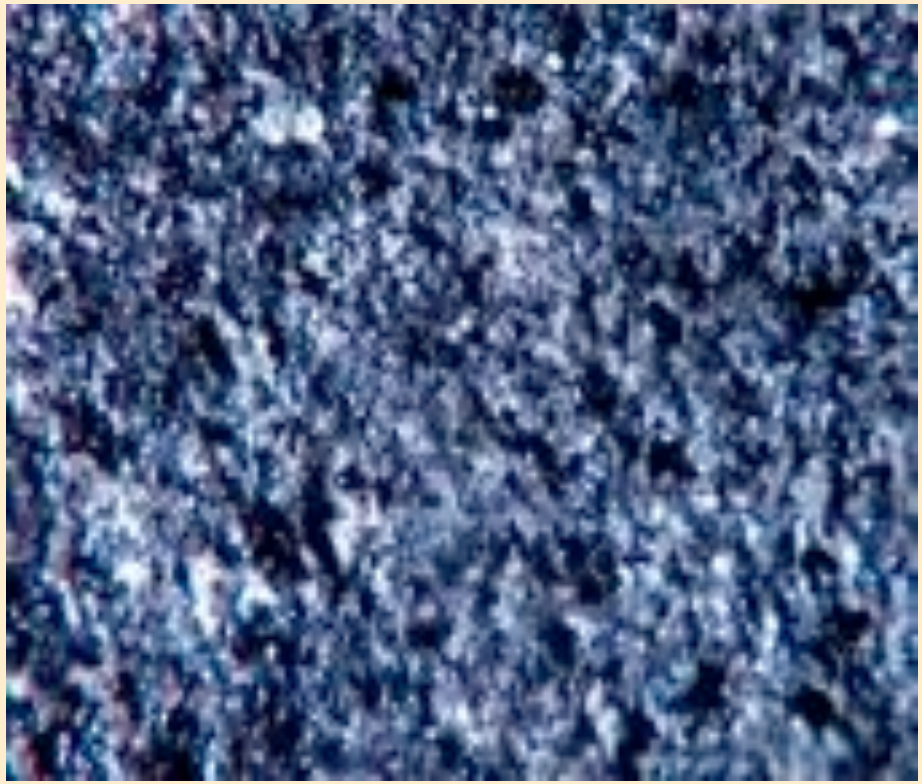


Counterfeit Examples



At higher magnification 50X appears to be an etched surface. See the surface at an even higher mag

100X look at the black glass spheres that make up the bulk of the plastic device body



Mystery solved this is a surface that has been etched

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Counterfeit Examples

Reported by Military OEM

Observations

-Marking is smeared - likely silk-screened
-No logo or OCM name – dodges IT laws
-Pin 1 dimple filled in - part is top coated.

Response from seller – another ID:

-Agreed parts marking “may have been” altered.
-Agreed sanded appearance, different top and bottom surfaces, pin 1 dimple not typical.
-Visual indicators are not valid because of age of component
-Sample obtained from “different seller” (not OCM) were the same in all respects.
-Did not observe these issues when we inspected them, please send parts back for re-inspection.
-OCM may have remarked them.
-We believe components are new and authentic

Response from IDT – the OCM

-Marking is incorrect, should be **ICS501MI**
-The "-" on the lot number indicates that this device has not been released to production.
-Lot number was assigned to a prototype lot.

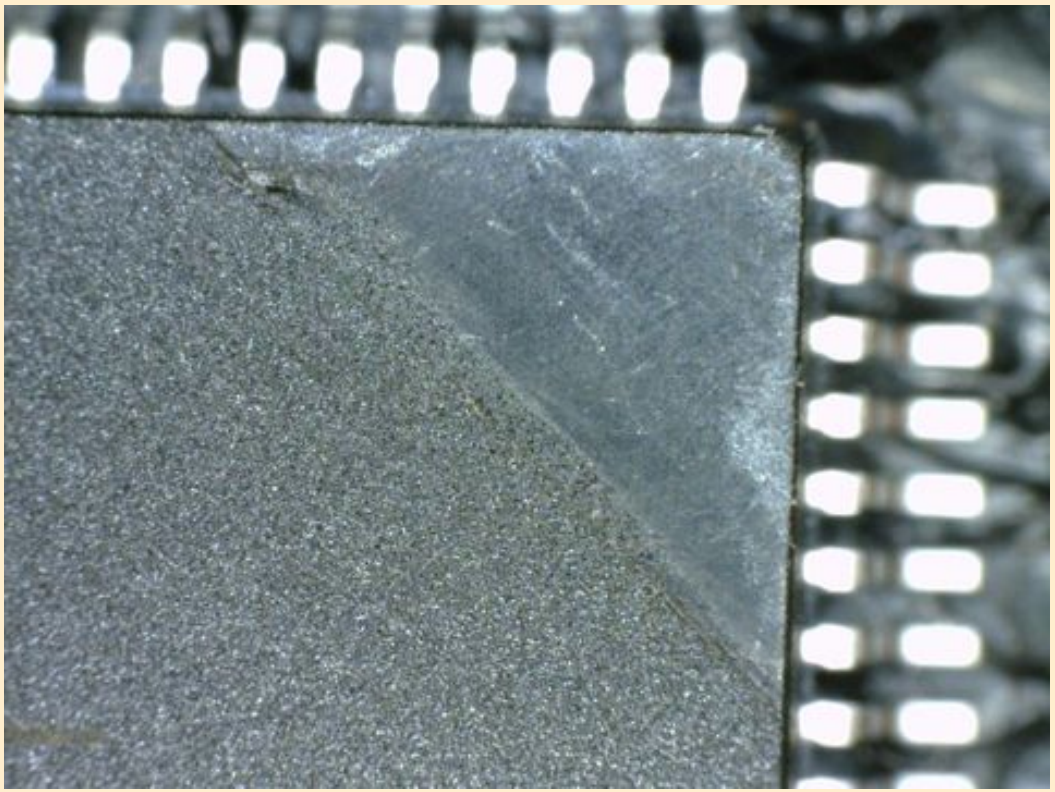
Conclusion

Components were judged to be counterfeit.

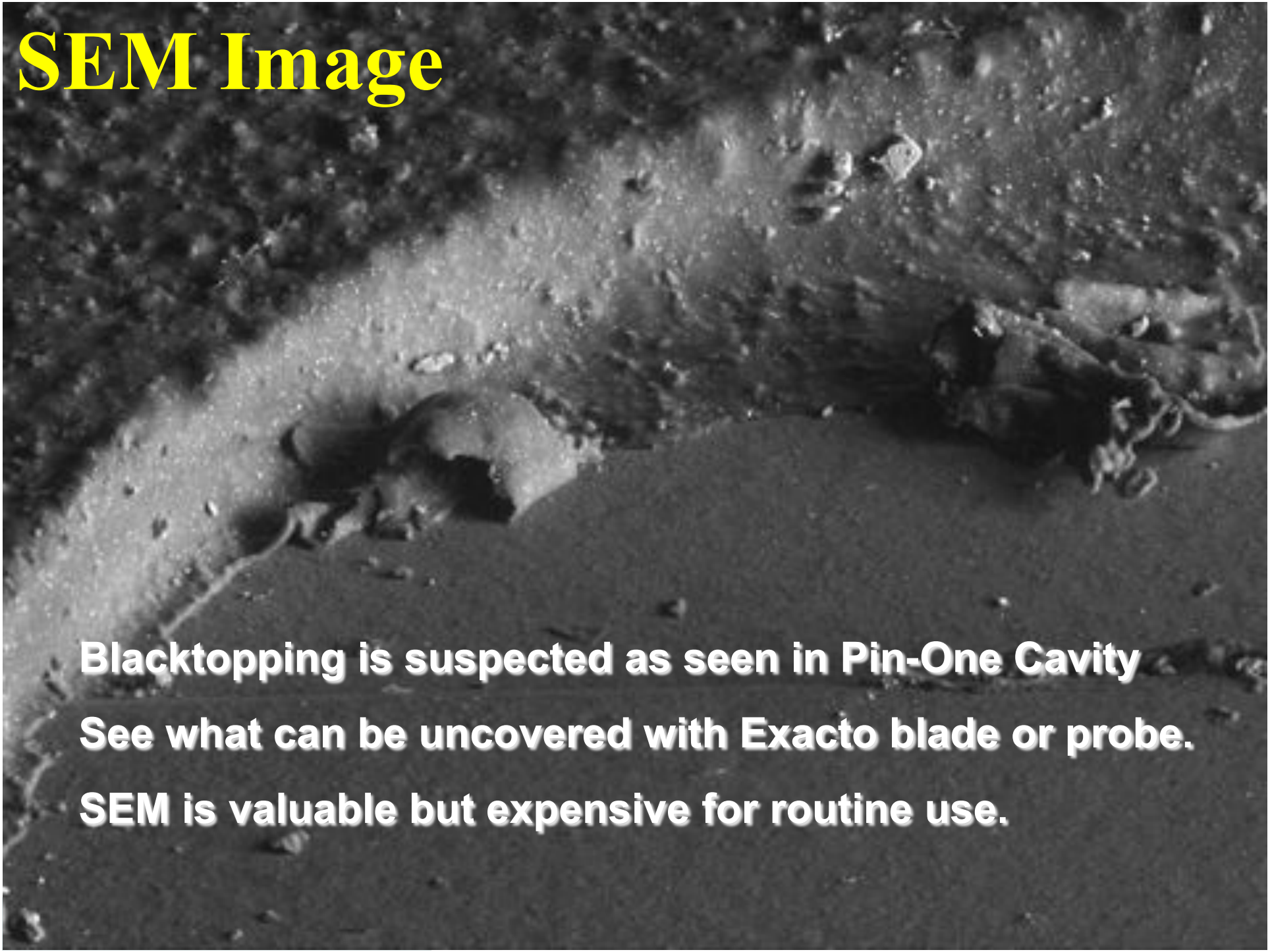
Counterfeit Examples

More Blacktopping

- Combination of scrape and sanding to expose the coating.
- Diligence is required to be sure.
- Further proof of scrape test when performed properly.



SEM Image



Blacktopping is suspected as seen in Pin-One Cavity

See what can be uncovered with Exacto blade or probe.

SEM is valuable but expensive for routine use.

Counterfeit Examples

Look at the black shiny paint substance in the lower right side, the mold pin cavity is almost gone, see the bent leads, it may have been painted over to hide sanding marks and then fraudulently remarked

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Counterfeit Examples

Obviously coated as attested by the covered mold mark and black residue around the end of J leads.

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Counterfeit Examples

Blacktop removed with acetone

Lower right quarter revealing the actual surface, arrow points at the pin mold cavity is filled

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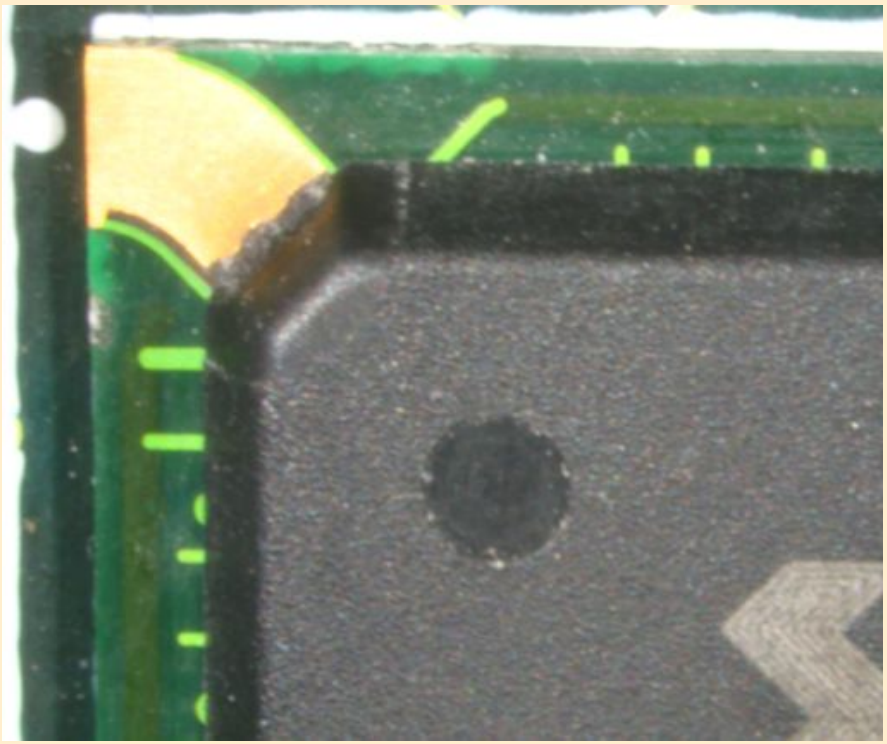
Counterfeit Examples

Surface texture difference indicates blacktopping.

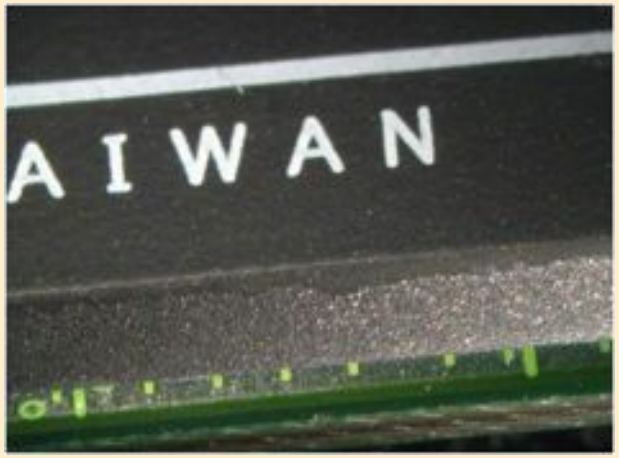
Counterfeit Examples

Authentic Xilinx markings



- Has Pin 1 & mold markings
- Does not show signs of black topping

Counterfeit Examples



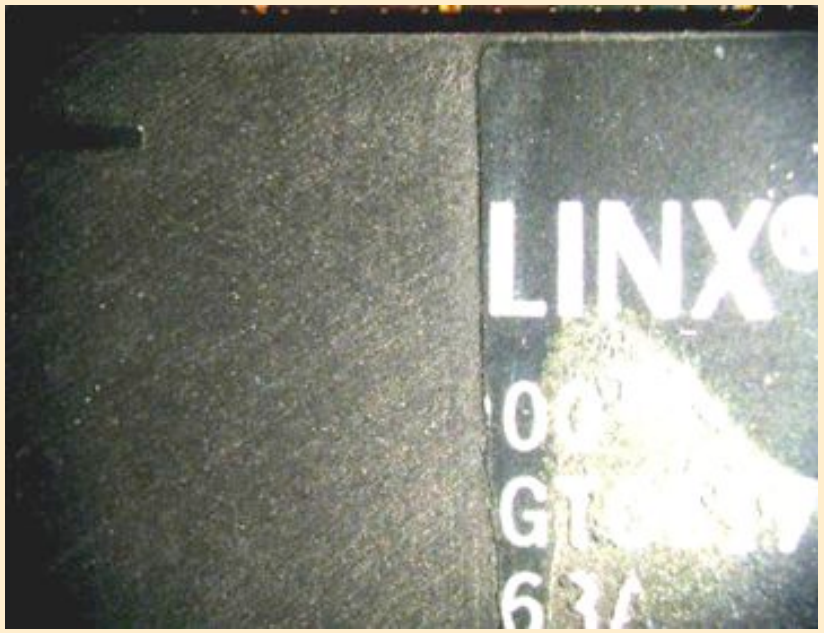
- **Visual inspection**
  - Ink marking looks good
  - Authentic parts were laser marked
  - No mold marks like on authentic parts
  - Edge shows a coating on the top.
  - Who remarked? OCM or Counterfeiter?

Counterfeit Examples

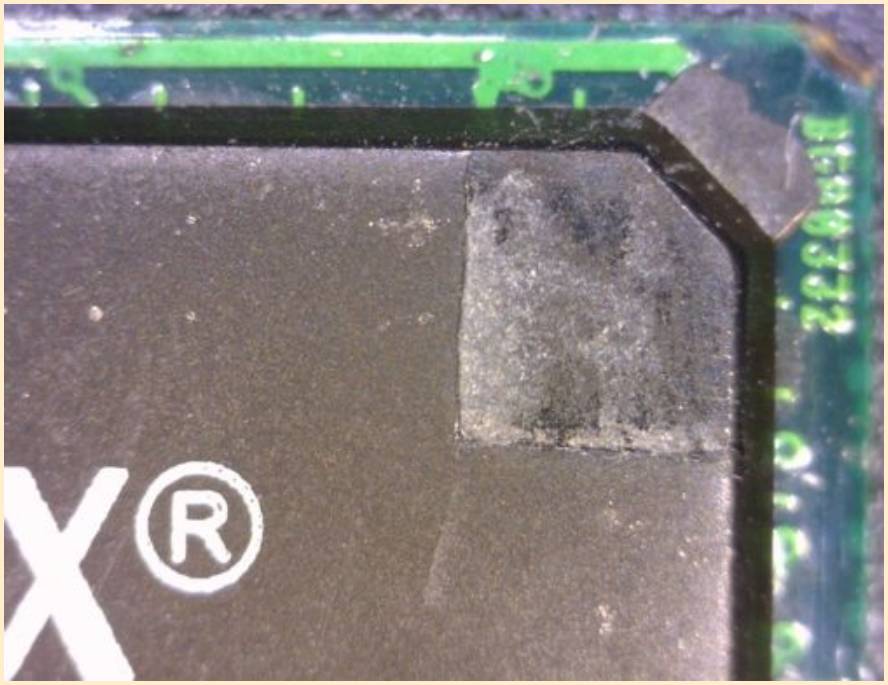
- Acetone-resistant blacktop
- Four different solvents were tried.
- Dynasolve 711 removed markings; but did not remove blacktopping
- Dynasolve 750 did not remove black coating.
- Unsatisfied, another solvent was tried.

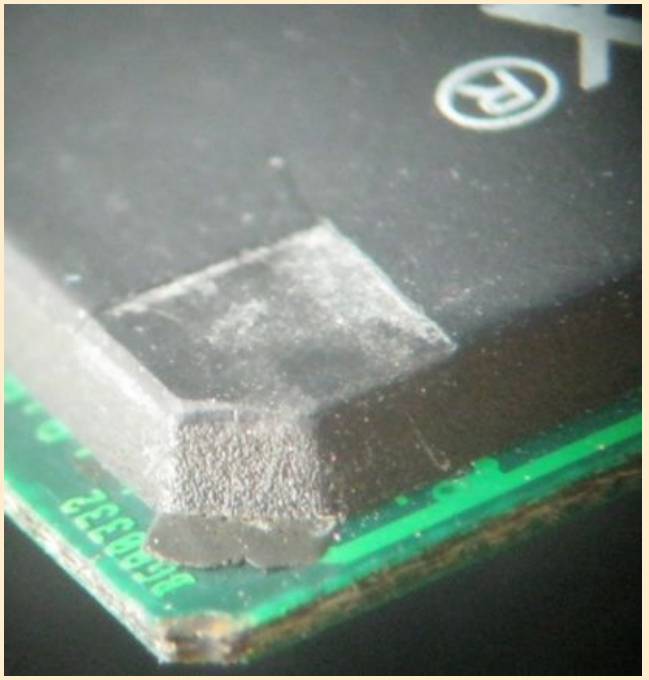
Counterfeit Examples

- Dynasolve's Uresolve Plus® was tried next – it removed the coating
- Sanding scratches under the blacktop were clearly visible
- Most solvents are designed for certain materials.
- HST may need a variety of solvents to detect cured epoxy coatings.
- This IC offered in 2 temps, 3 speeds & could be cause for remarking.
- Supplier changed markings to provide a newer date code – making it a "counterfeit by remarking."
- **Customers should not request newer D/C on components especially those identified as obsolete?**



Counterfeit Examples





- Blacktop coating was definite & soluble only in Uresolve Plus.
- Easily removed with scrape test.
- The scrape test is a substitute for HST but no view of sanding marks.
- Package material appears to have out-flowed onto interposer board.

Counterfeit Examples

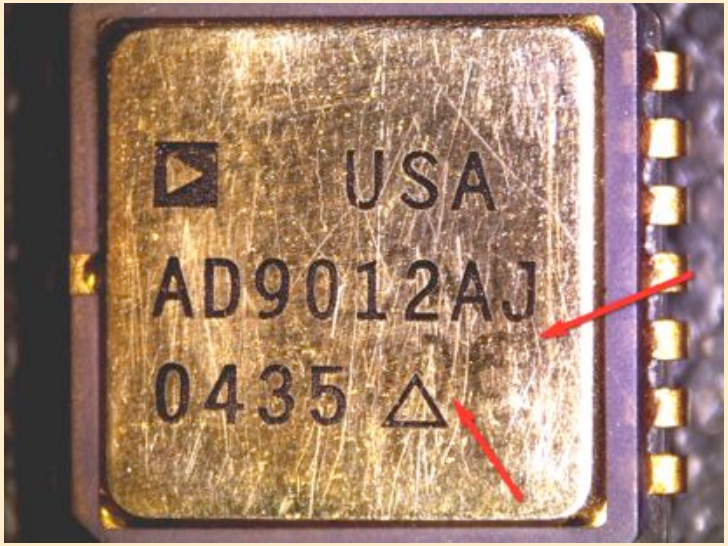
MVP Manufactured Part numbers

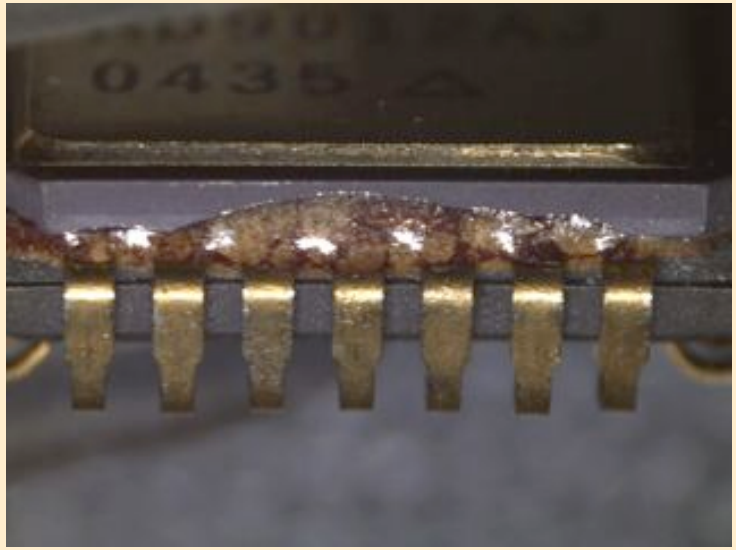
Quicklogic	QL12X16B-1CG84M	
Intersil	ICM7170AIBG	
Actel	A3265DX-1PQ1001	
TI	OPA627AU	$50
National	LM10H/883C	$75
TI	SMJ320C30	$1750
AD	AD9220AR	$25
AD	AD5962-8871902MXA	$629
AD	AD664TD-BIP/883B	$510
TI	3656AG	$449
TI	SMJ34020AGBM40	$720
AD	JM38510/11302BEA	$33
TI	JM38510/32502BRA	$37.89
TI	JM38510/65705BRA	$37.89
BTB12-600SWRG		$0.90

- Were not all recovered
- **Be on the lookout for these**
- Should have Au wire ball on old ball bond.
- Requires decap & careful inspection to find.

Counterfeit Examples

AD9012AJ





Counterfeit Examples

Lids appear to have been sanded & remarked

- Ghost markings are visible
- TI will not confirm they remarked parts.

Counterfeit Examples

Counterfeit Confusion
Remarking looks like counterfeit

← **Ghost markings**

Part was remarked by Fairchild,
does that make this part a counterfeit ?
NO

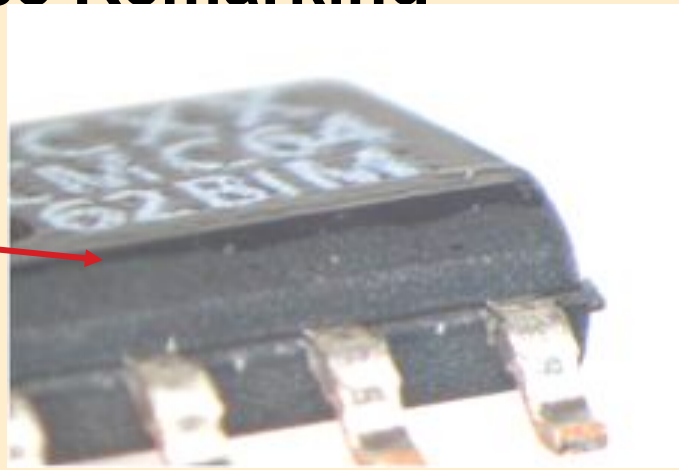
- Obsolete part purchased by C-ID from Rochester Electronics.
- Rochester certifies part as received from Fairchild.
- Fairchild QC Manager verified the part had been remarked & was authentic.
- Fairchild had the parts remarked by a subcontractor to downgrade.
- **Without OCM C of C part should be classified as Counterfeit.**
- Some OCMs are not controlling the quality of their markings.

Counterfeit Examples

Counterfeit Confusion
National Semiconductor - Device Remarking

Note remarking

See black topping



NSC Response

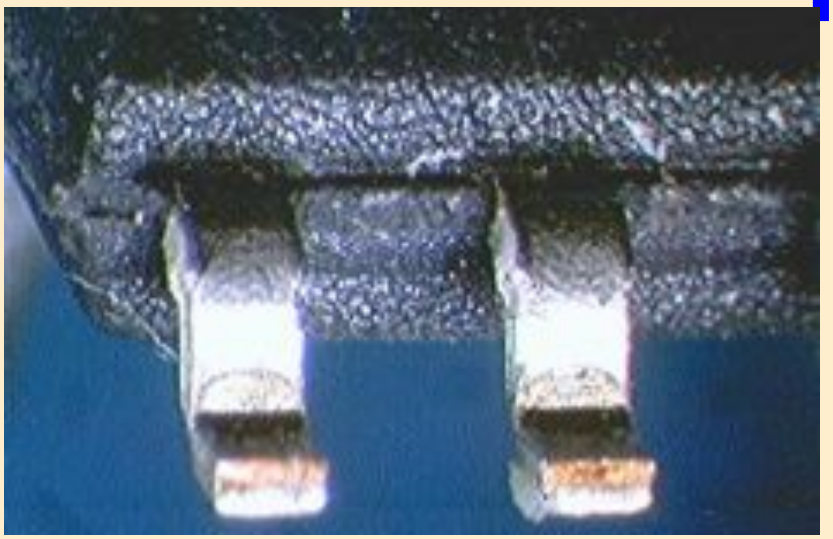
"Parts were remarked for downgrading, only looks like counterfeit. "

- This date code was shipped to Future Electronics (FD).
- NSC claims this is their process for downgrading parts.
- That is why the laser marks underneath ink mark can be seen.
- "As long as bought from OCM Authorized distributor, they should be fine."

Customer Service Support
National Semiconductor Corporation

- **OCM should provide notice of remarking with shipment.**

Counterfeit Examples



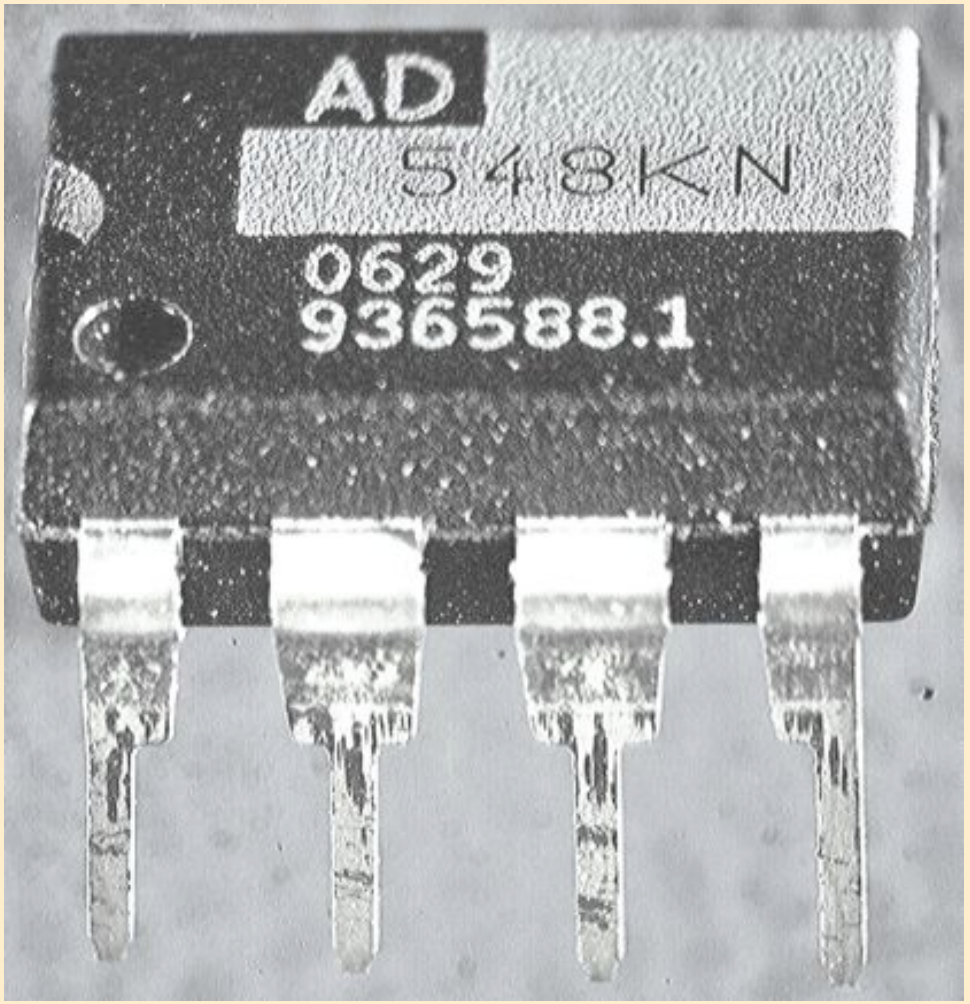
- Example of places to inspect on leads for indications of previous use. End of leads do not show solder from previous use, but bottom of leads do.
- This one is difficult, exposed Cu looks OK, but solder thickness on lower part of right lead are signs of previous use, probably a reduced solder attach process.
- Makes this component “suspect”, needs further positive prove of authenticity.
- “Exposed copper” on lead ends is NOT a defect and may be sign of authentic, now being done by spot plating or copper paint.
- Components with “suspect” characteristics must be declared Counterfeit.

Counterfeit Examples

Leads and Marking

This IC did not leave the factory looking like this:

- No logo, has to be black topped
- Poor re-tinning
- Two very different fonts.
- Not typical of AD marking.



Counterfeit Examples

Left half is the remaining coating after acetone cleaning

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Counterfeit Examples

After acetone cleaning

Close up of coating, not as good as some

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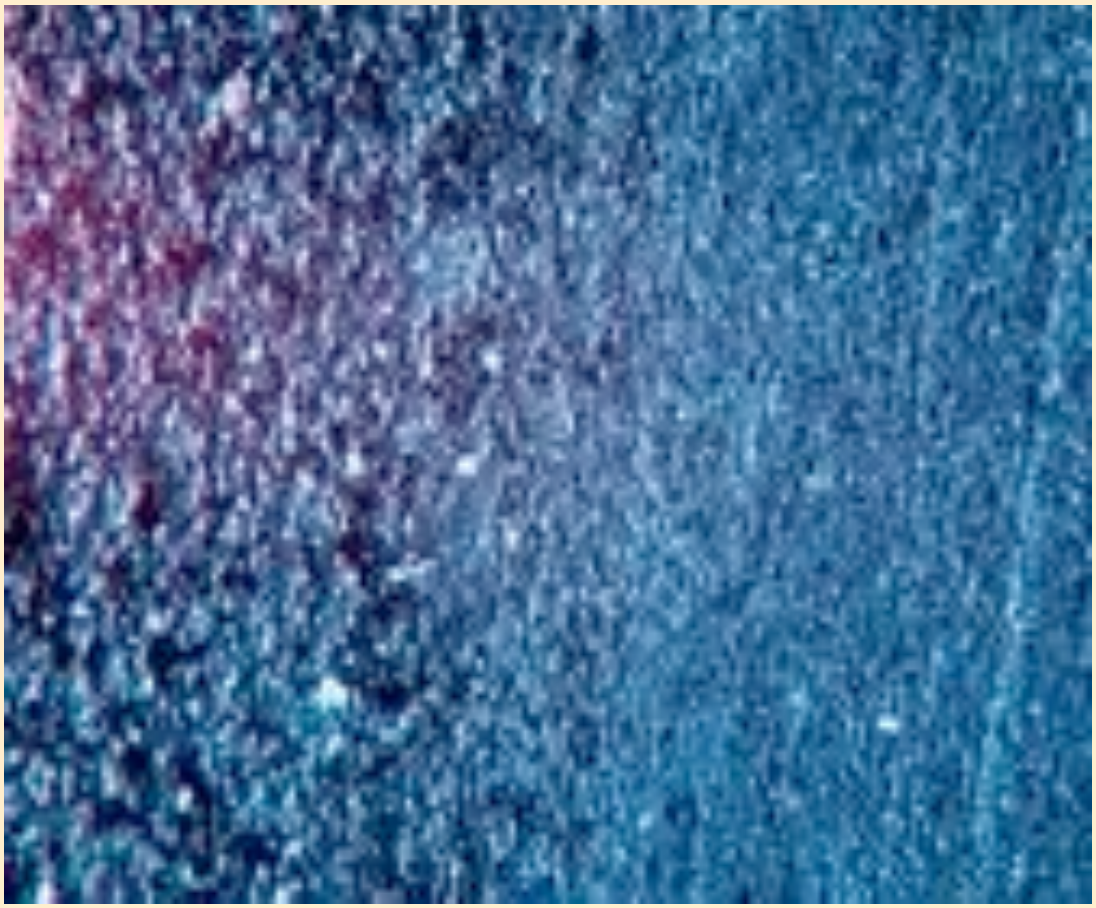
Counterfeit Examples



Much higher view of surface

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Counterfeit Examples

Obviously sanded and altered

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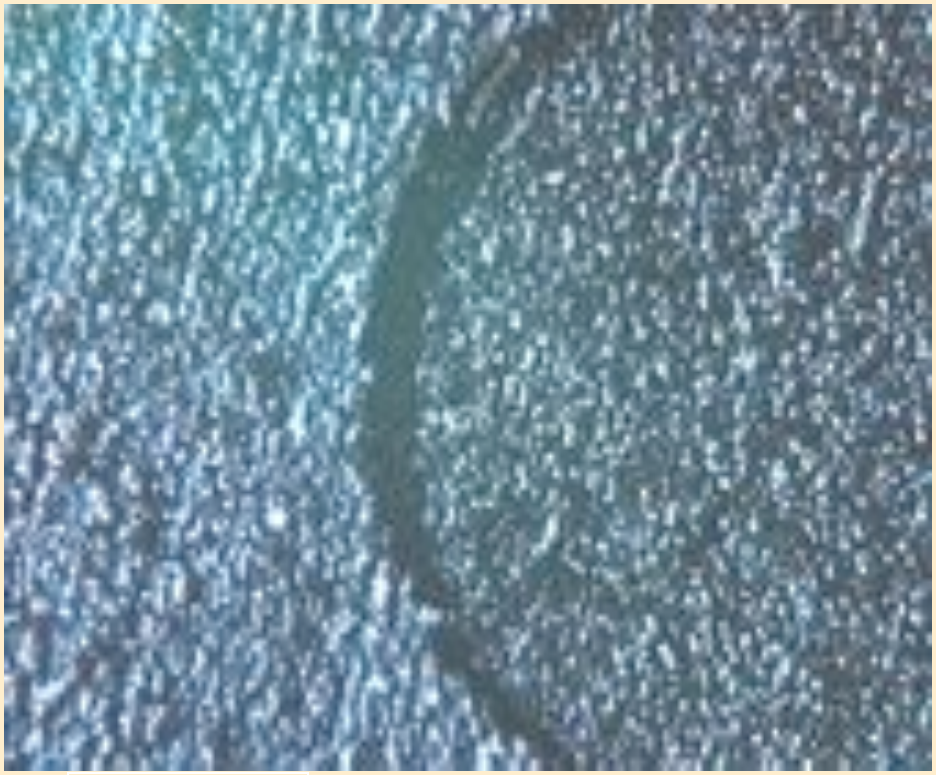
Counterfeit Examples



PIX 1

PIX 2

100x Pix #1 showing surface coating covering the mold pin cavity, Pix #2 after acetone cleaning

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Counterfeit Examples

See a dull grainy appearance, it is apparent that the top surface has been altered.

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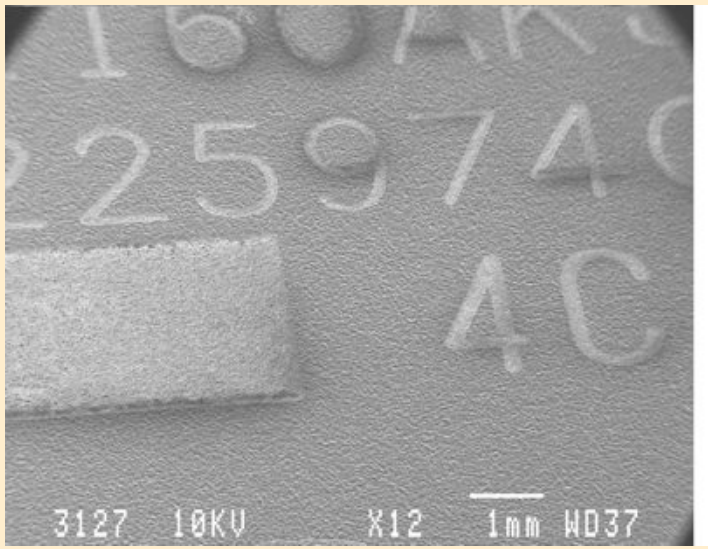
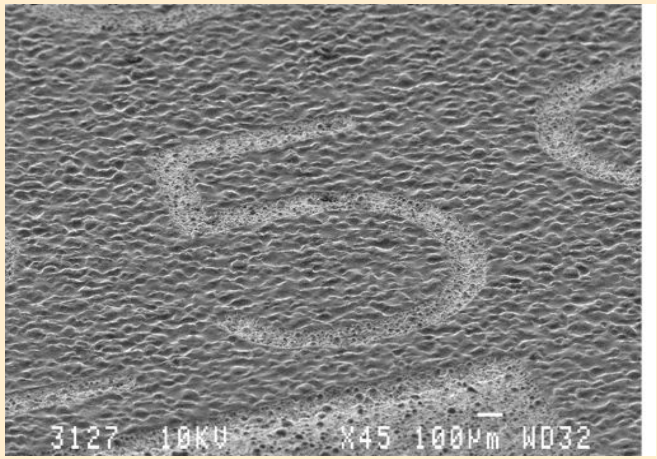
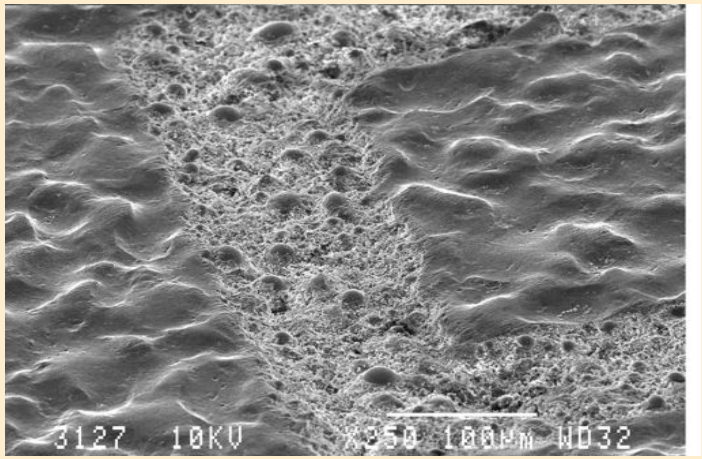
Counterfeit Examples







SEM detail of IC, appears to have been remarked by the manufacturer.

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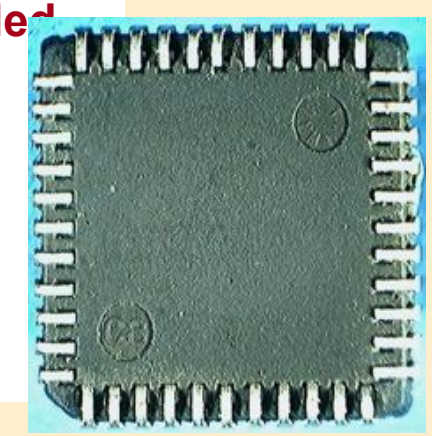
Counterfeit Examples

OBSOLETE, REMARKED

- IC was discontinued about 1996; no licensed re-manufacturer.
- Parts likely electrically good, ruined by clean-up.
- Purchases several brokers deep. Stated they never had a complaint about electrical malfunction.
- Re-marking to raise price, update, or “clean-up.”
- Re-marking trademark, changes part to counterfeit.
- Samples sent to US Customs authorities.
- Manufacturer registered his logo with Customs.
- Surface Texture differential test - failed
- Pin 1 Dimple Reflectivity and Depth Test - failed
- Lead-form and Co-planarity Test - failed
- Mold Mark Reflectivity Test - failed
- Acetone Swab Test for Blacktopping - failed



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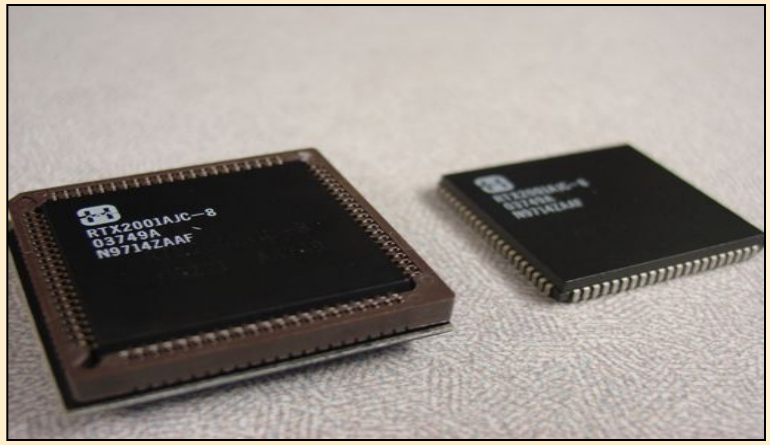
Counterfeit Examples

GHOST MARKINGS

- Microcontroller in board of mature design has peculiar markings.
- Black-topping too thin, original date code readable with careful lighting.
- Original 9221 date code changed to 9714.
- Tracing through suppliers could not provide evidence of OCM up-dating.
- Appears change for obsolete part.
- These ICs could have been recovered from old boards, de-marked, blacktopped, remarked, tested, updated and possibly up-rated.
- Parts worked in the application.
- CANNOT BE AUTHENTICATED.



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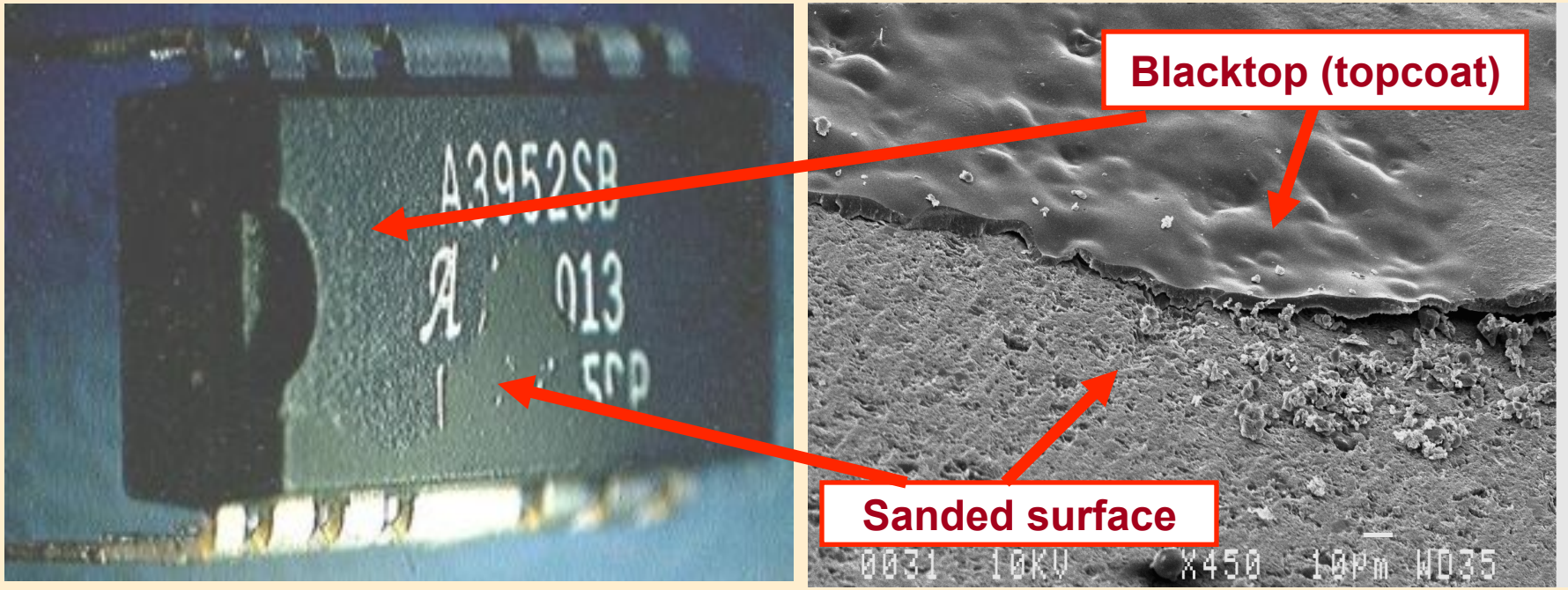
Counterfeit Examples



REMARKED. Markings sanded off. Blacktopped. Allegro logo illegally tampered. Blacktop peeled away with normal process handling, taking markings with it. SEM photo at right shows detail of differences in texture of coating (top) and sanded surface (bottom). Striations in the sanded surface were made by abrasive grains (450x).

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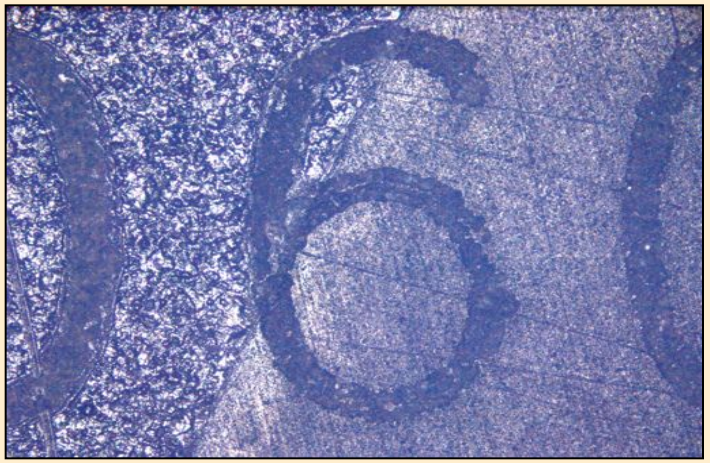
Counterfeit Examples

OBSOLETE PART REMARKED.

- **FPGA**
- Blacktop fails acetone swab.
- Incoming flagged first shipment, sent parts back.
- Second shipment had same problem.
- Customer granted permission to use only after passing stringent sample testing plan.
- Part was remarked with lower-speed P/N in order to satisfy market demand.
- Still counterfeit per CCAP-101.



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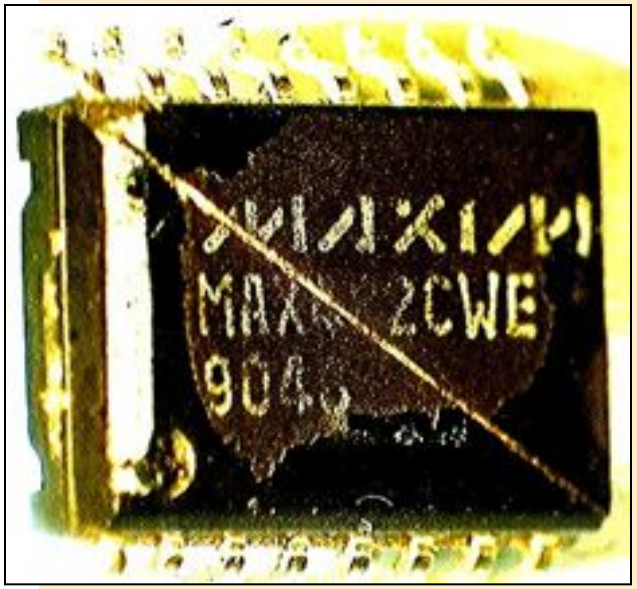
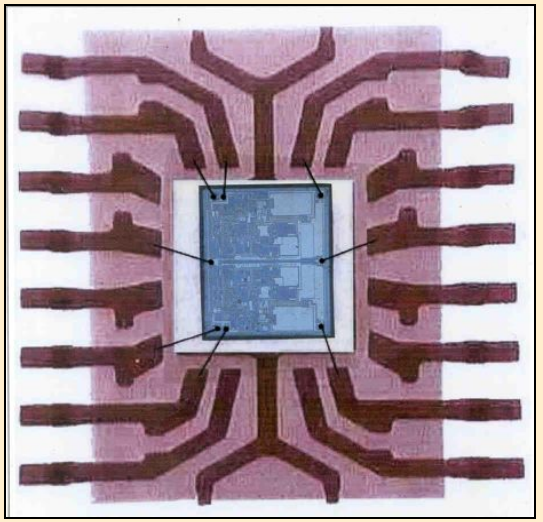
Counterfeit Examples

BLACKTOPPED

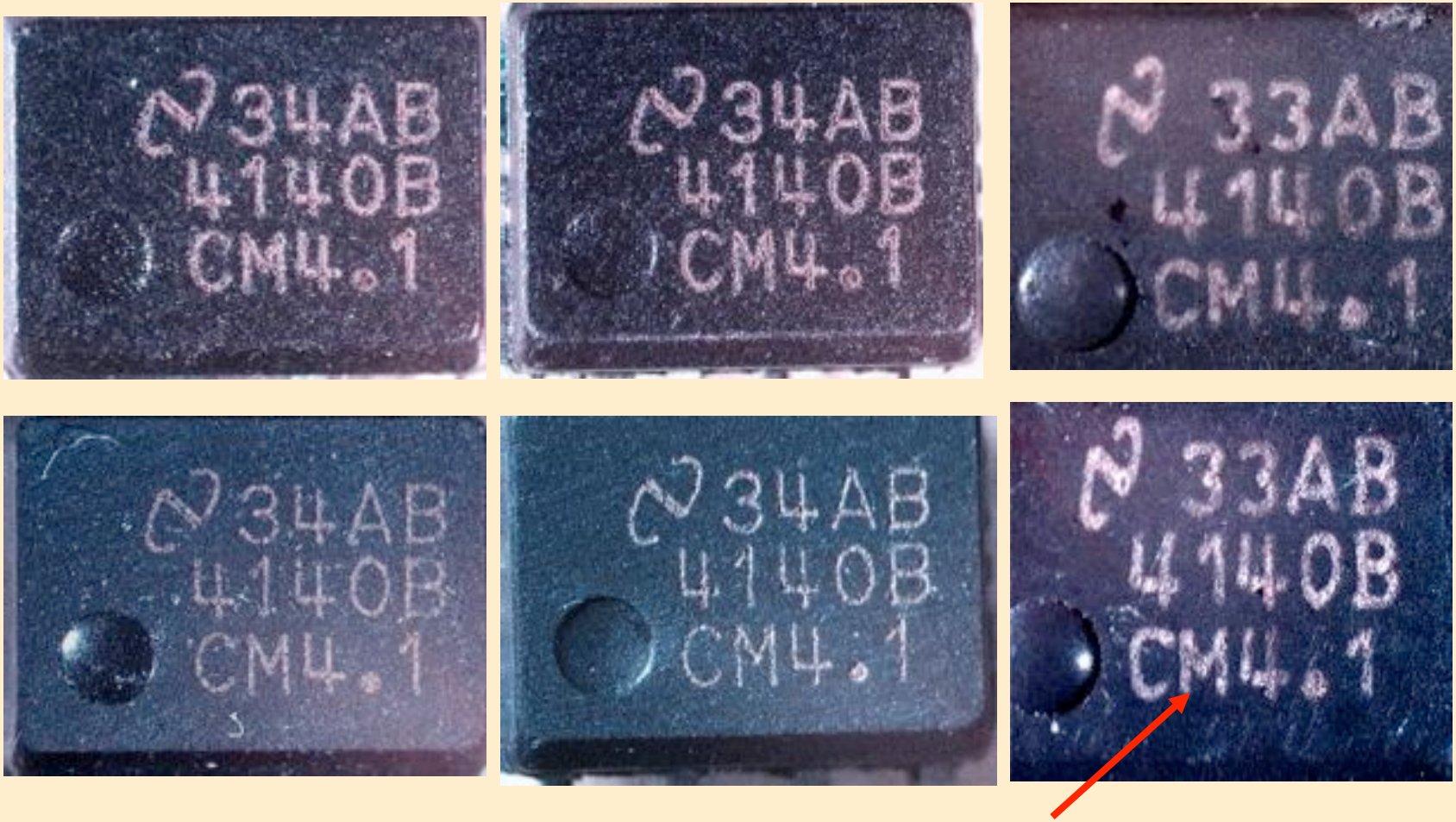
- Blacktop not soluble in acetone
- Parts marked with correct part number for order; Maxim OP90GS
- Wrong pin count and wrong package type.
- Black topping or “Top coating” peeled or flaked, revealing a different Maxim part number beneath
- Maxim has no record of this part number.
- De-capping showed Maxim logo on die, but die is not correct type for the OP90GS part.
- Maxim Security was contacted, sample parts and copy of FA report was provided for their investigation.
- Photo is composite assembled during FA.
- Die drawing for correct die (black and white), and die found in package (color) were totally different.





© Thomas Lee

Counterfeit Examples



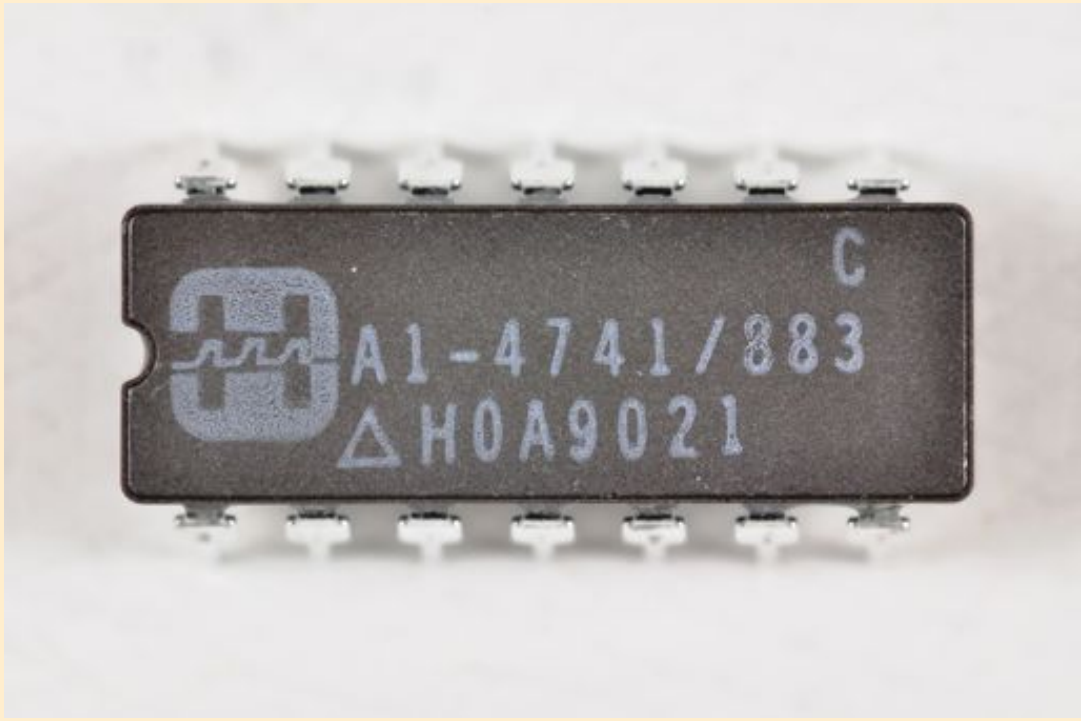
The characters are incomplete, faded, compare the surfaces to each other, all are from the same lot, the laser mark is inconsistent, sanding marks can be seen

Courtesy & Copyright Custom Analytical Services

Counterfeit Examples

Harris Markings

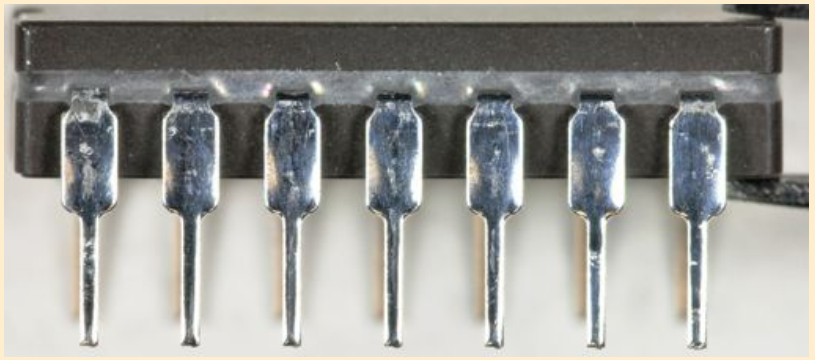
- 1990 date code CERDIP.
- Ink marking was in use.
- There are signs of ink removal, faded except logo
- The top line of mark is not centered horizontally.
- Harris data sheet needs to be researched for correct logo and if 883 C was offered.
- Most likely remarked.



Counterfeit Examples

Harris Markings

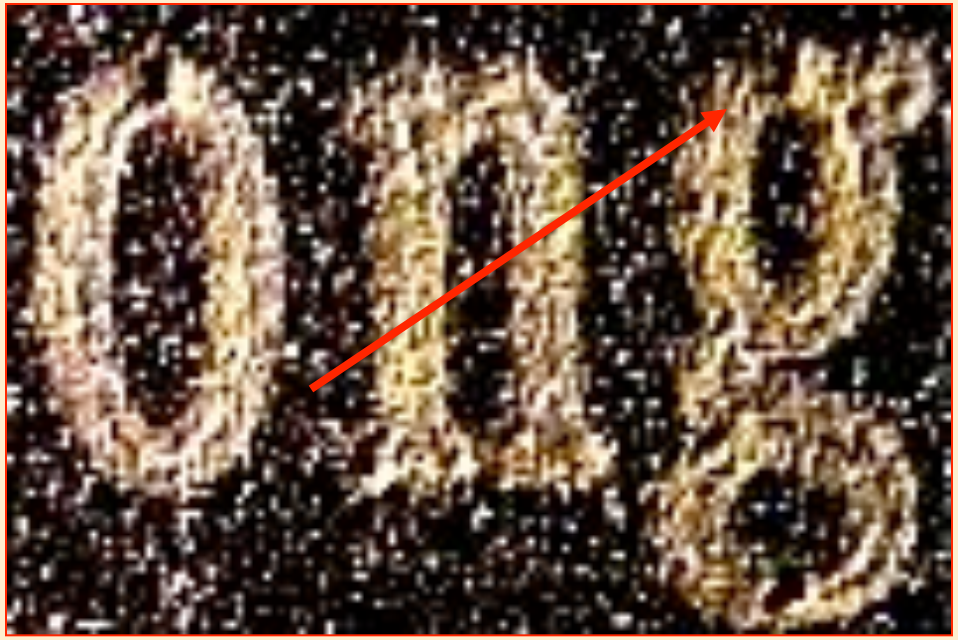
- Leads very bright for 22 years.
- Looks recently re-tinned.



Counterfeit Examples

Laser marking needs to be looked at carefully. The problem is that not being the best funded operation they buy used and after market equipment for the laser marking and
very often the result is poor.

The arrow points at a hole in surface created by the laser burn, the bonding wires could be seen through hole.

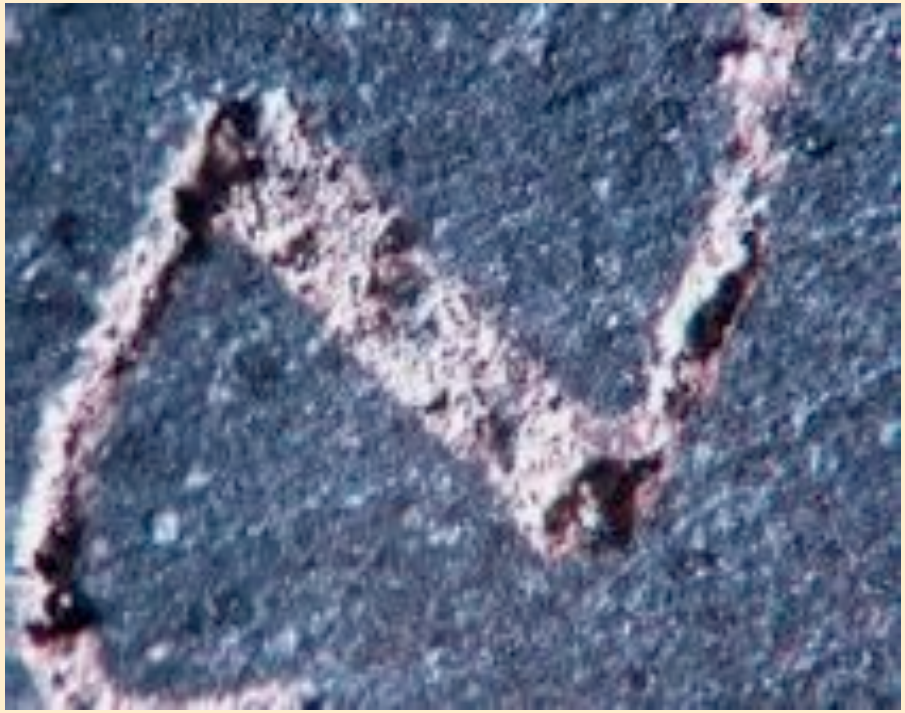


Courtesy & Copyright Custom Analytical Services

Counterfeit Examples

Based on the appearance of the previous slides, these are strongly suspect as have been fraudulently altered.

With chemical cleaning the surface coating comes off revealing the sanding marks beneath



When there is laser damage look closer- not typical of OCM.

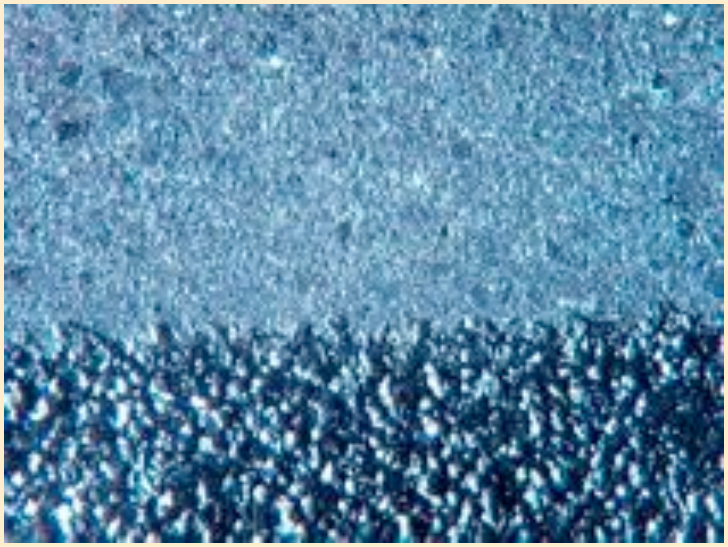
Courtesy & Copyright Custom Analytical Services

Counterfeit Examples

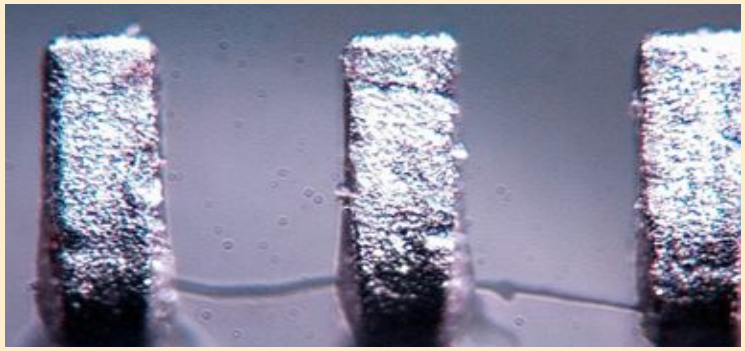
Most parts with Laser damage are in some way bogus, plus Philips would not abbreviate their logo. Decap revealed the chips were not original Philips, components were remarked.

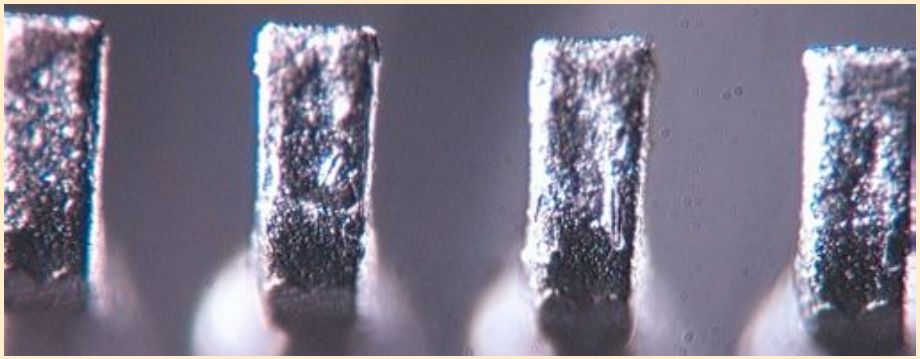
Courtesy & Copyright Custom Analytical Services

Counterfeit Examples



The surface was scrubbed with acetone and the coating came off, the sanding can be clearly seen

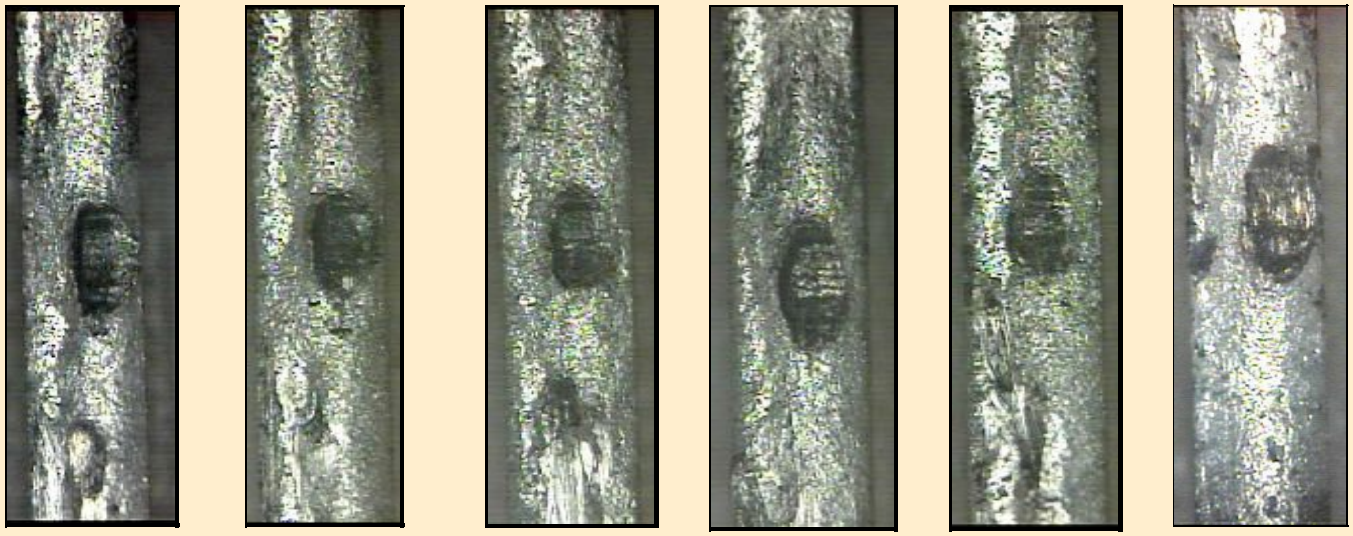




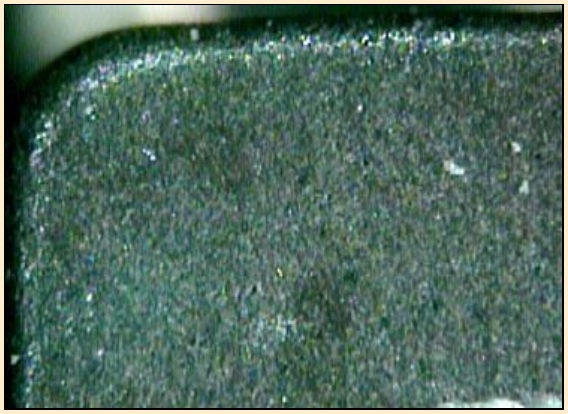
See the refurbished leads

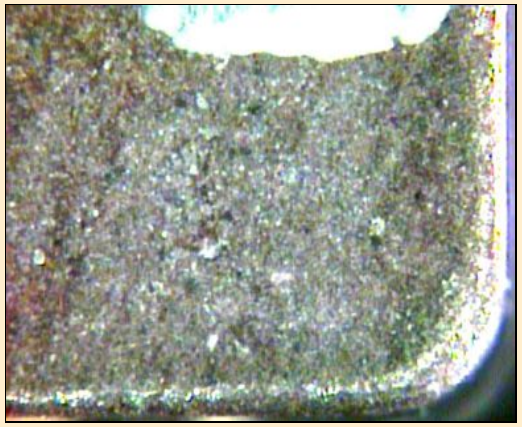
Courtesy & Copyright Custom Analytical Services

Counterfeit Examples

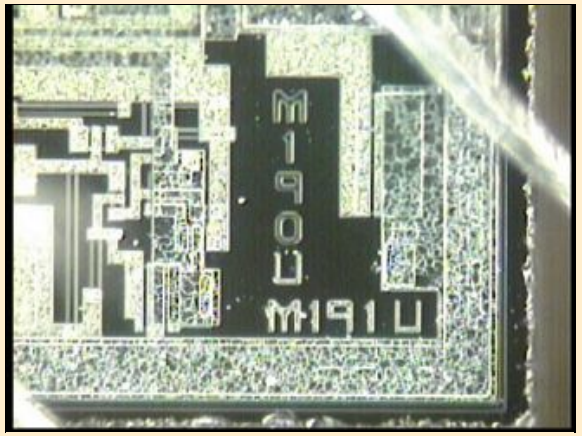


The damage can be clearly seen at this level of magnification





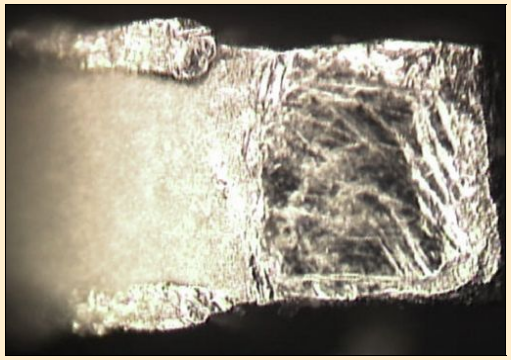
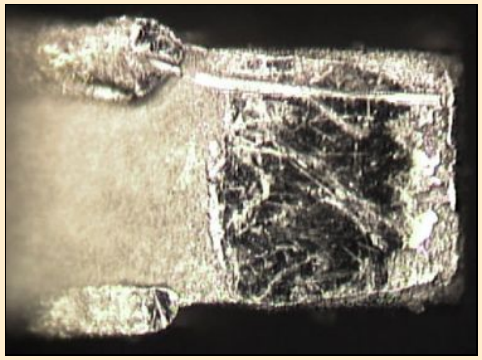
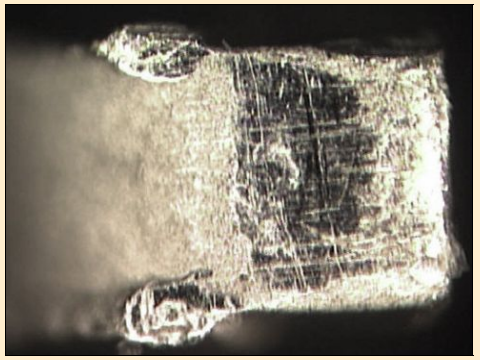
The corners show excess wear, probably from sanding.



The chip seen after decap not surprisingly it matches the marking

Courtesy & Copyright Custom Analytical Services

Counterfeit Examples

Reclaims: the malformed contact portion of lead with lumps of solder attached to the back, is the remains of the original solder attachment when they were pulled from a board

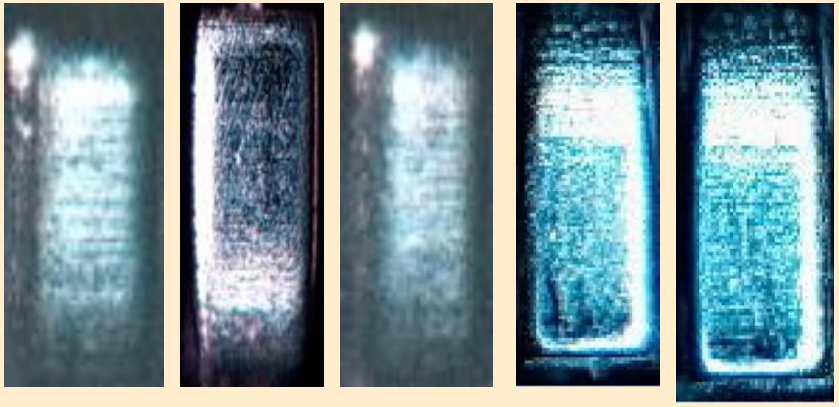



Ends of leads,bent twisted obvious pulls

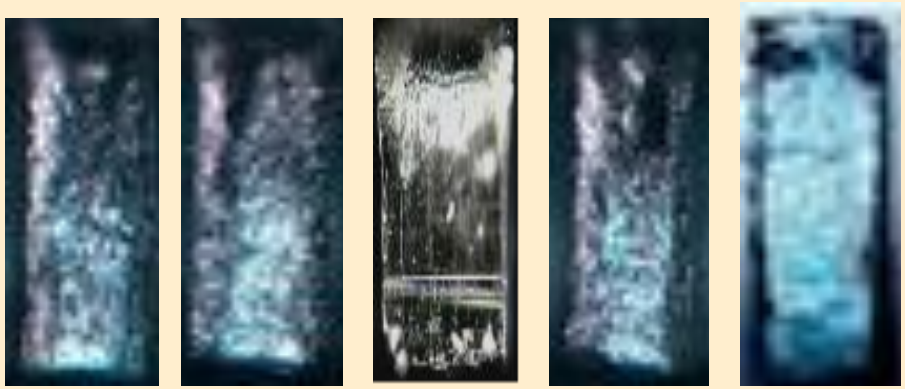
Courtesy & Copyright Custom Analytical Services

Counterfeit Examples

- All leads should be straight, and aligned.
- Solder remains often cannot be seen with the naked eye



New unused leads.



Leads of reclaimed ICs

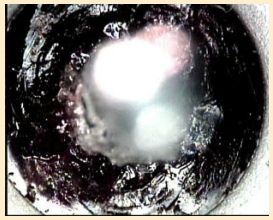
Courtesy & Copyright Custom Analytical Services

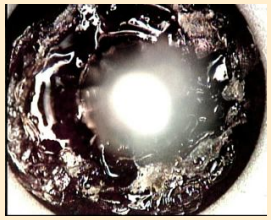
Counterfeit Examples

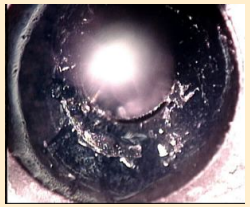
Transistor - Signs of Mounting

To-3 transistor a few hundred million of them made, they are very widely used in mil electronics.

Pulls!!! See the lock washer indents and metal washer bruises







Pins of glass to metal seals, are cracked & splintered.

Courtesy & Copyright Custom Analytical Services

Counterfeit Examples

Recent Incident- MIS19837-88 *Apr. 2012*

Reported by Incoming Inspection

- Suspect lead dimensional issues
- Failed electrical test, 60% yield

Materials Failure Analysis

- Leads breaking at a noted weld point
- Markings failed solvent permanency tests, even peeling with tape
- Peeling and flaking plating, failed external visual inspection

Part Information & History

- Out of production, $91.00 each
- Purchased from ID Source in 2010
- ID source acquired from MVP?
- 3rd Confirmed TO can incident in 4 years

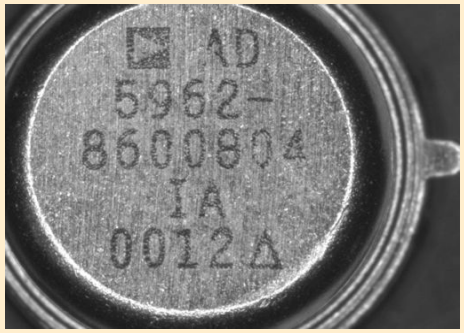
Courtesy Aaron DerMarderosian, Raytheon Corp.

Counterfeit Examples

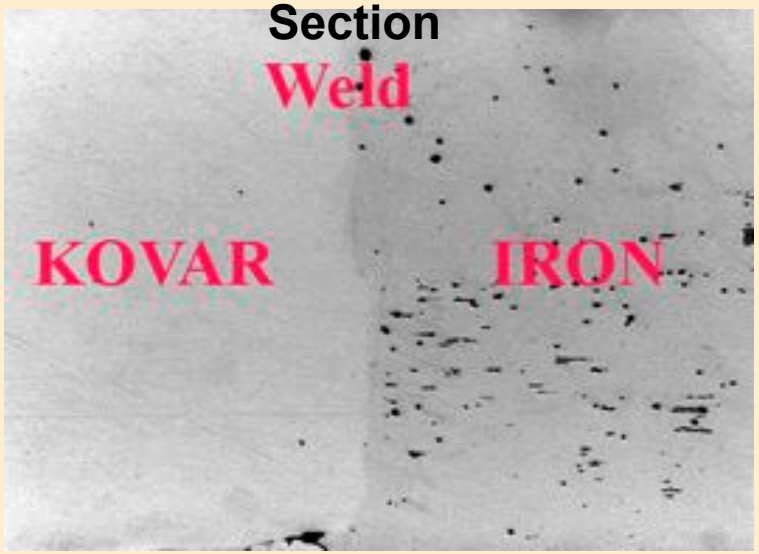
Lead Extensions- *Evolving Techniques*

Genuine Device
Voltage Comparator

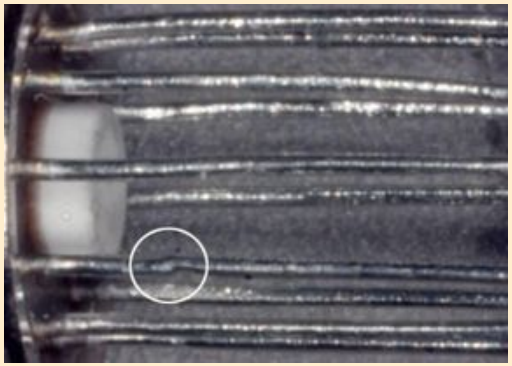
Suspect Device
Top Sanded

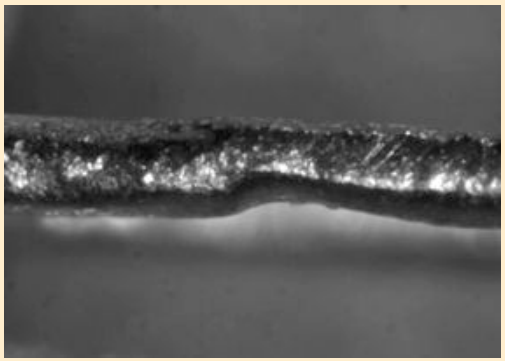


Suspect Lead Micro-Section



Solder Plating Uneven - Bend in Lead Detected





Kovar Lead Exiting Glass Seal in Can

Iron Lead Welded to Kovar to Extend Length

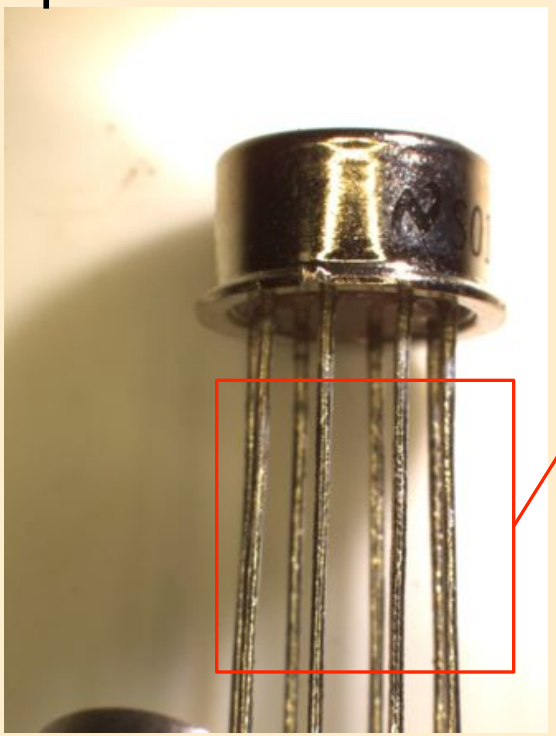
Solder plating obscures lead extensions

Courtesy Aaron DerMarderosian, Raytheon Corp.

Counterfeit Examples

Incident: Op-Amp *Sept. 2011*

L0024H/883 (MIS-19837/04) Hi-Rel Op-Amp out of production since 1998 – see D/C 0012



No evidence of lead weld deformation

Terminations breaking during lead-forming process, leads visually appeared undisturbed

Courtesy Aaron DerMarderosian, Raytheon Corp.

Counterfeit Examples

Package attributes, observations

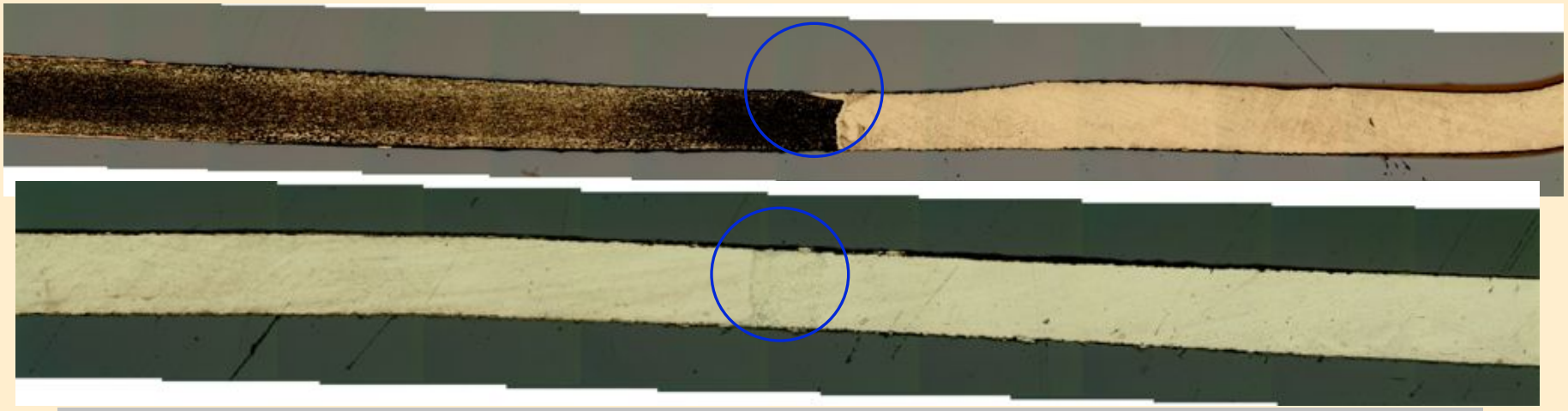
Sanding marks visually evident on some components

"E" discriminator- multiple lots, markings & marking quality inconsistent

Courtesy Aaron DerMarderosian, Raytheon Corp.

Counterfeit Examples

Lead Extensions- Weld zone comparisons



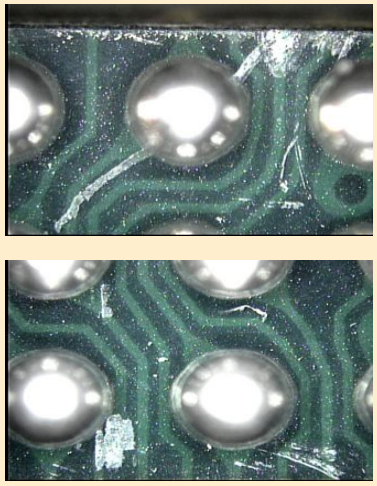
Two termination constructions revealed during cross-sectional analysis

Iron-Kovar & Kovar-Kovar extensions evident & structurally weaker

Courtesy Aaron DerMarderosian, Raytheon Corp.

Counterfeit Examples

Device as received.
Look at how well done



BGA side - heavy gouging going across is give away

Top surface magnified

Drop of fuming Nitric acid

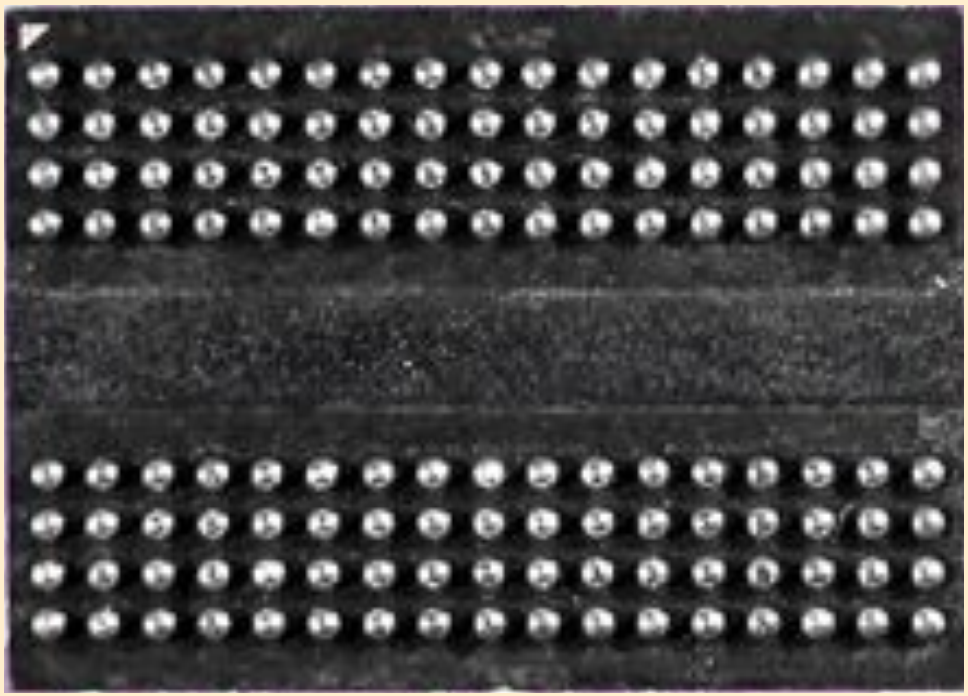
then clean with acetone.

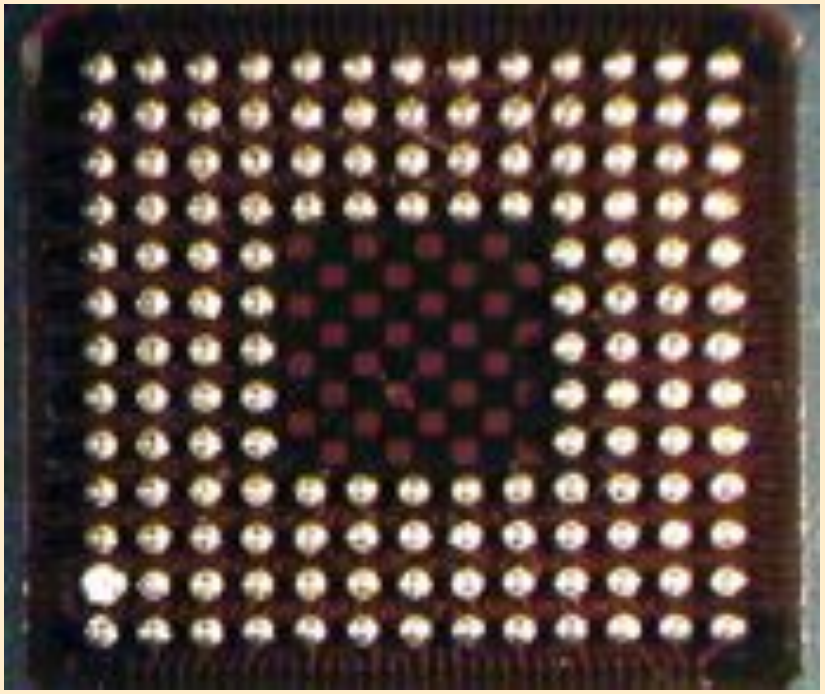
Known good plating.

Courtesy & Copyright Custom Analytical Services

Counterfeit Examples

The magic of GOOD Optics- light field/dark field

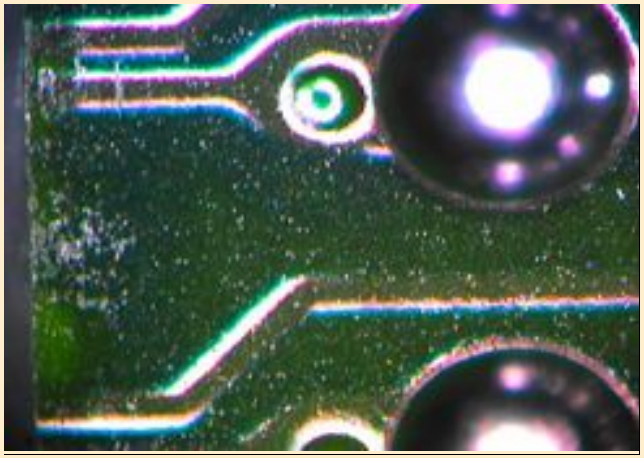


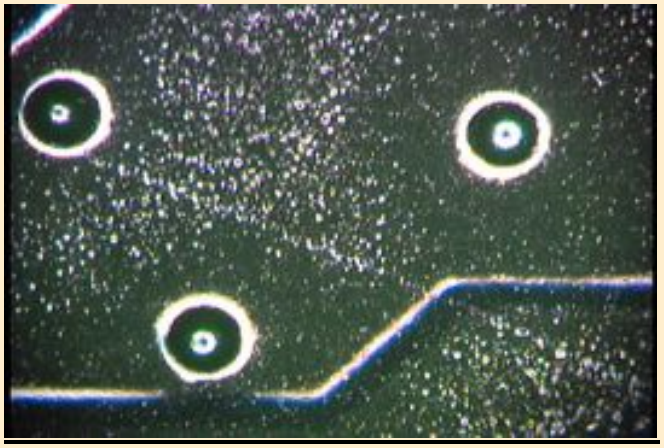


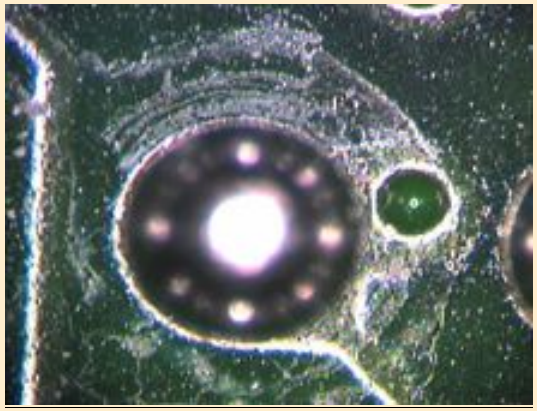
The Art of re-balling a BGA part is well understood and is being practiced every day. As seen in the previous slide, up until recently, it was relatively easy to see the parts were re-balled.
Requires good OPTICS and look for what used to be the the obvious, they are now hidden.

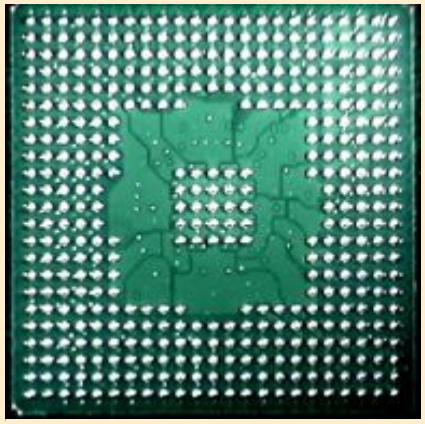
Courtesy & Copyright Custom Analytical Services

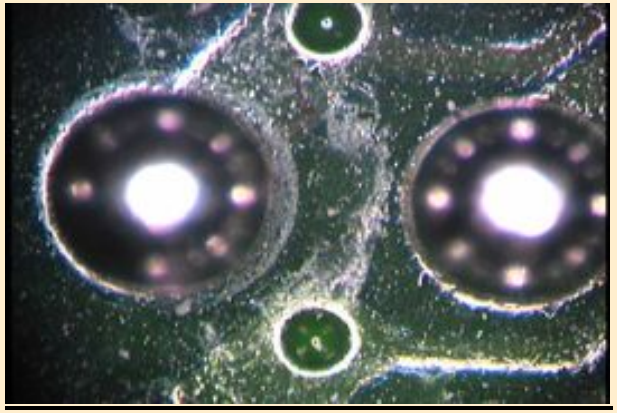
Counterfeit Examples









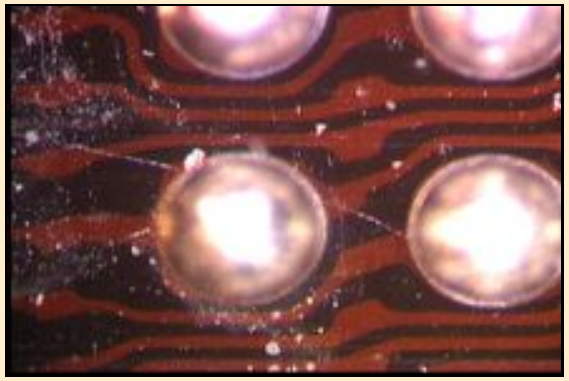
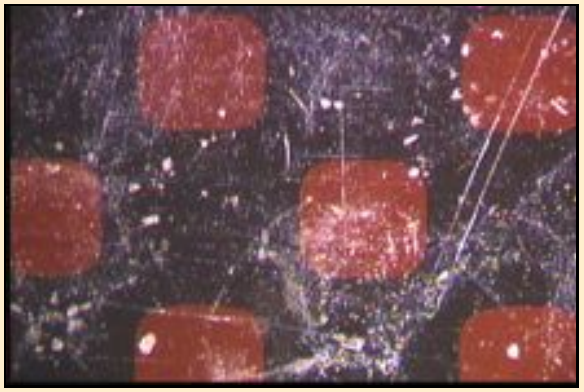
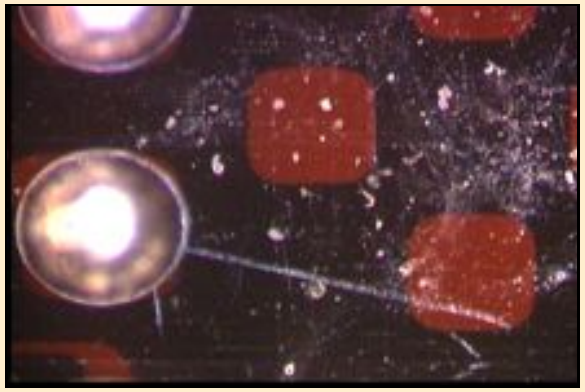
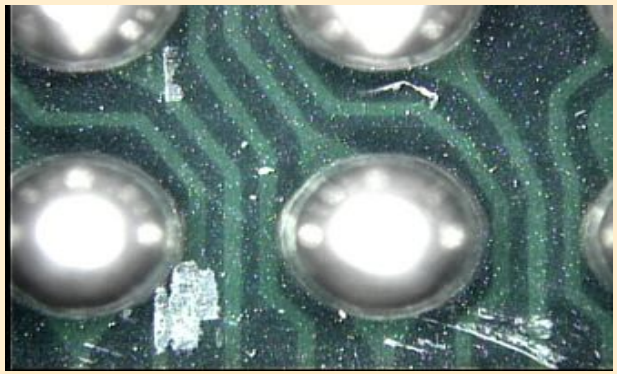
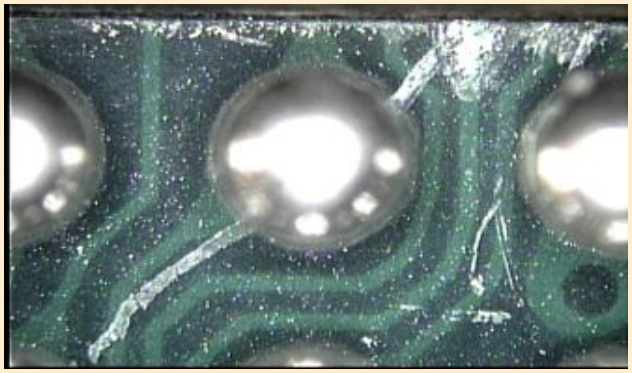


The only purpose of this slide is to highlight the colors. As you will see in the next slides the parts that are being refurbished today have a coating that hides the debris, gouging & scratches

Courtesy & Copyright Custom Analytical Services

Counterfeit Examples

At first look the rework was rather obvious with scratches going thru the plane of the balls, indicating that the ball was not there when scratches occurred, combined with the dirt and remnants of the cleaning effort indicate re-balling and COUNTERFIT.

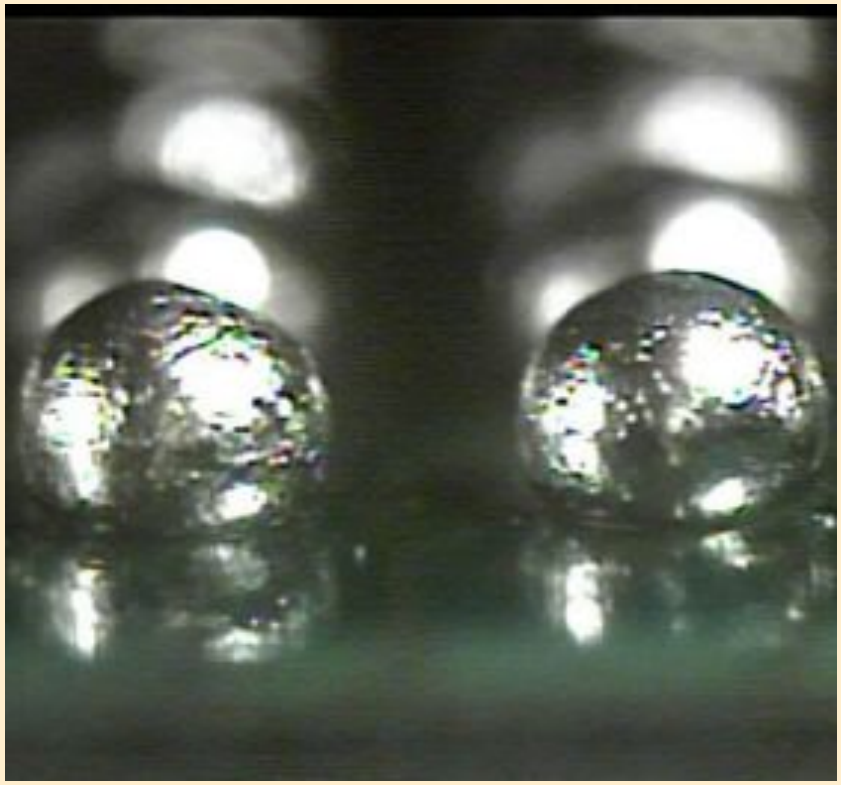






The parts are scratched and dirty color differences.

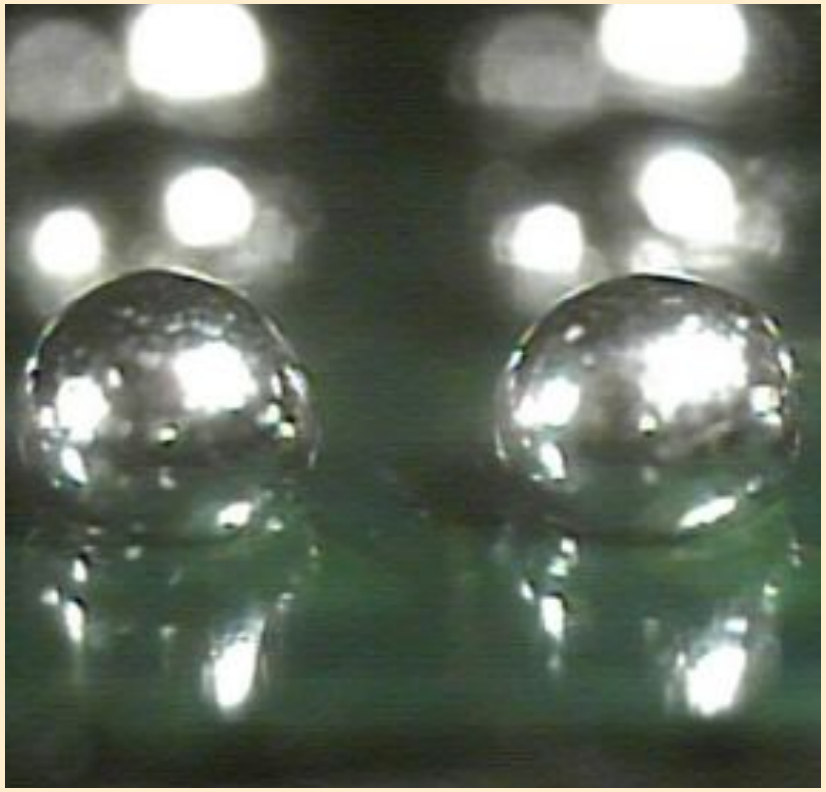
Courtesy & Copyright Custom Analytical Services

Counterfeit Examples

What to look for when inspecting BGA's



Known new device, dimples are expected



Bright shiny? Probably re-balled

Courtesy & Copyright Custom Analytical Services

Counterfeit Examples

BGAs

Edge is badly damaged

Probably residual flux

This type of damage or contamination should not be seen on supplied OEM part

Courtesy & Copyright Custom Analytical Services

Counterfeit Examples

All of these are from fraudulently altered parts

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Counterfeit Examples

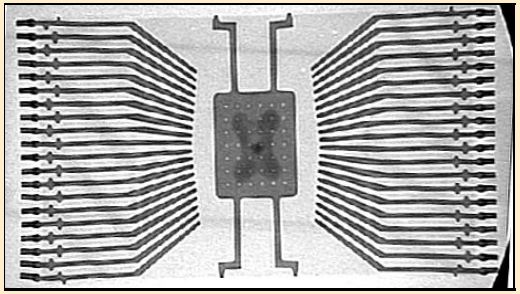
Purpose of X-Ray

- Visual comparison of internal construction prior to decap.
- To determine uniform construction characteristics to make sample inspection meaningful.
- Characteristics to check for (not always visible with X-ray)
  - Lead frames are the same size?
  - Do they contain a die and same size?
  - Do they have bond wires?
  - Do bond wire connections conform to OCM data sheet?
  - Can damage be seen that may have caused OCM to scrap component?
- Observed differences may invalidate use of sampling and further consideration of components as authentic.

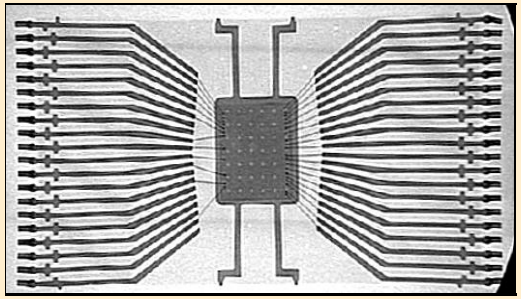
Counterfeit Examples

Value of X-ray Inspection

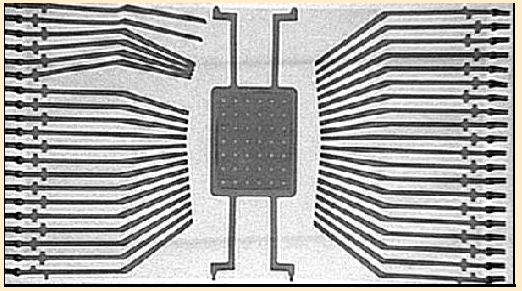
Use random samples from the lot to see if all parts have consistent construction. This is a good way to spot a mix. Do they have die? Do they have bond wires?



No wire bonds –

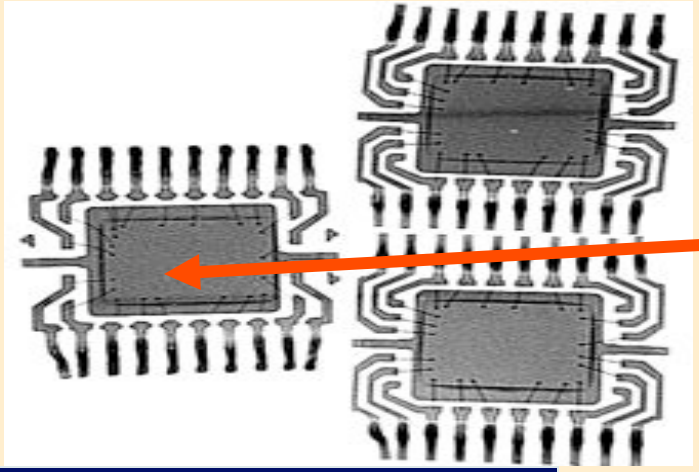


some wire bonds



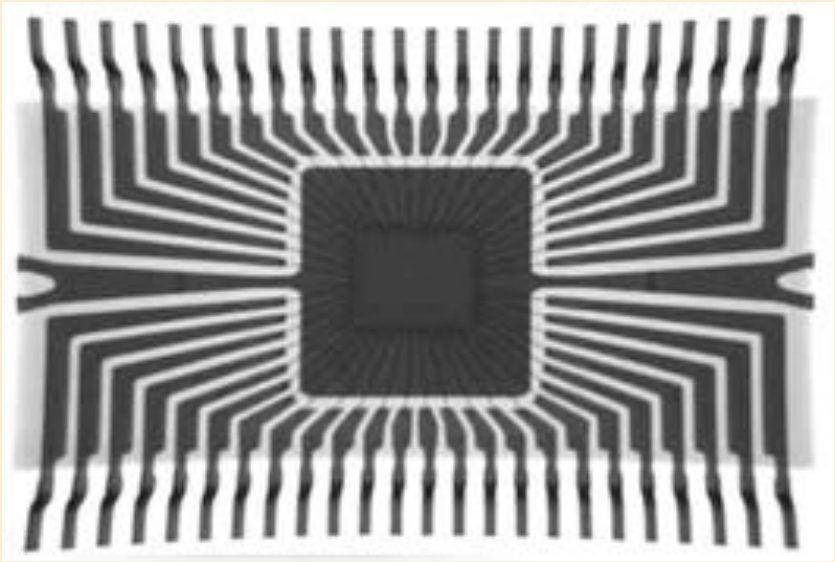
no wires but bent frame

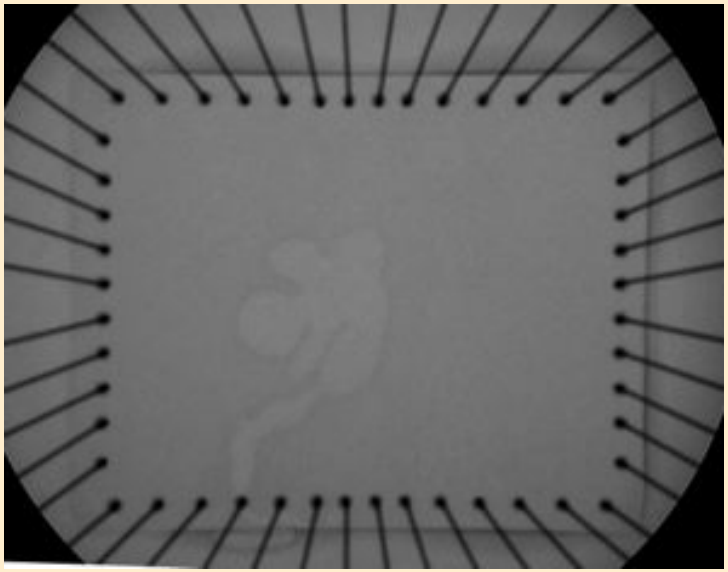
These parts are most likely "DUMPSTER DIVE" OCM Scrap.



The single package on the left , has a different wire bond structure, these parts do not match and are counterfeit.

Counterfeit Examples

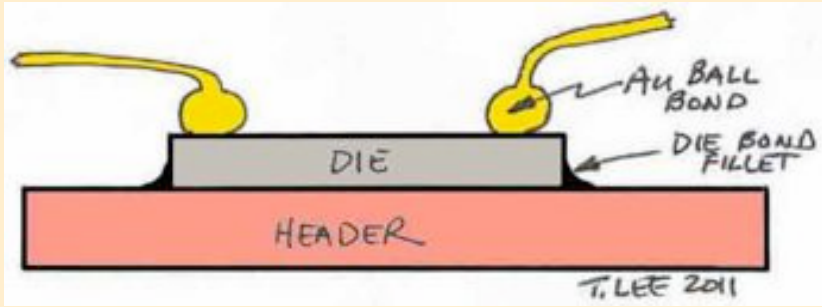




X-Ray Analysis

Bottom image is a high mag view:

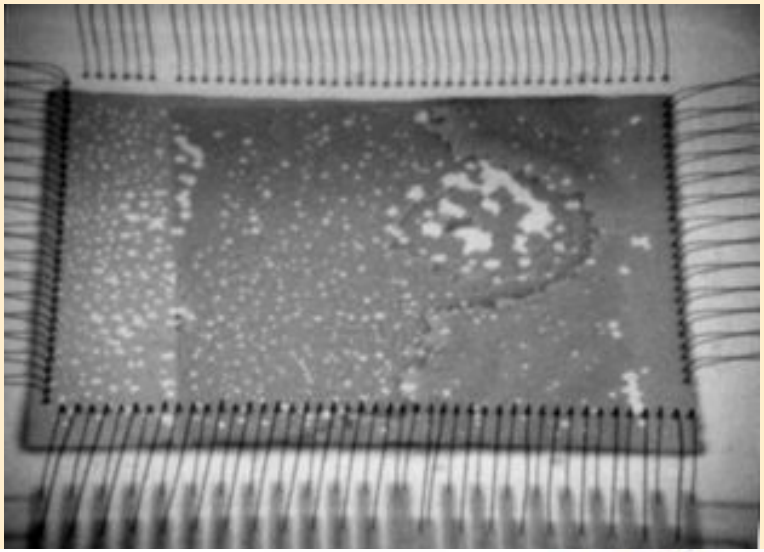
- Provides greater detail and resolution
- Hi mag & full view are different images.
- Requires storage to view together
- Sketch is a cross-section of IC construction.

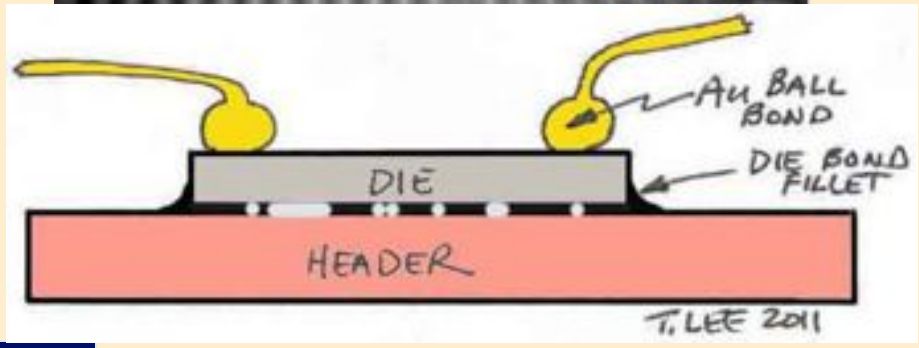


Counterfeit Examples

X-Ray Analysis

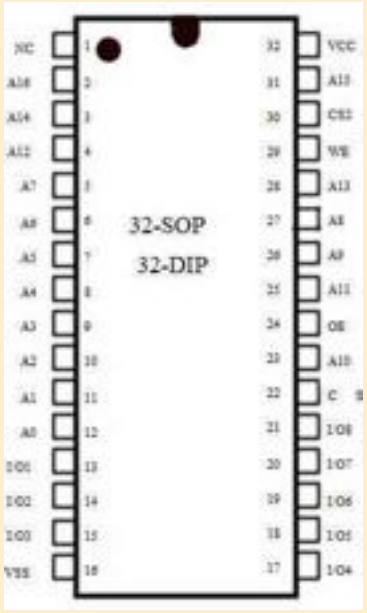
X-ray may reveal OCM quality issues which may not be related to being a counterfeit component:

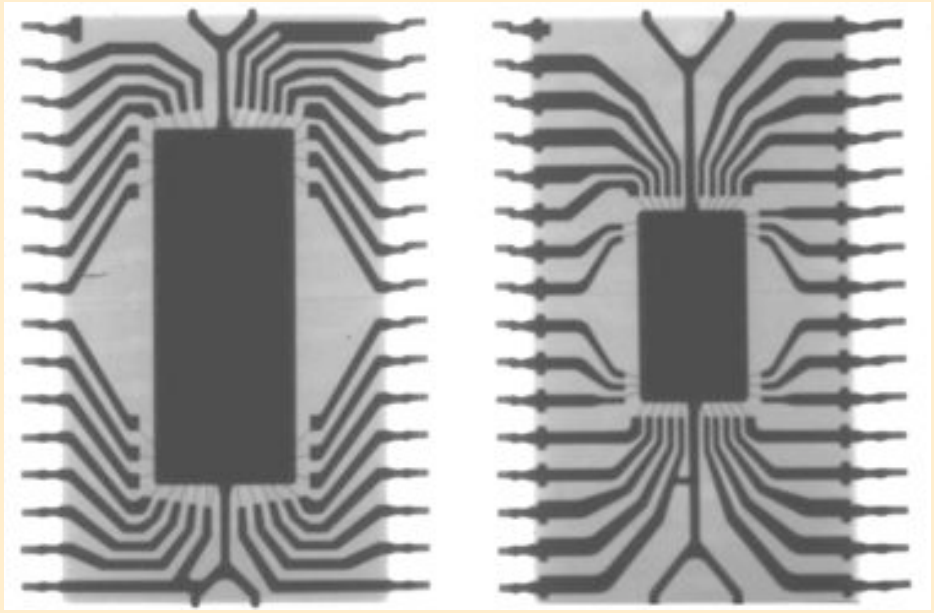




Counterfeit Examples

X-Ray Analysis



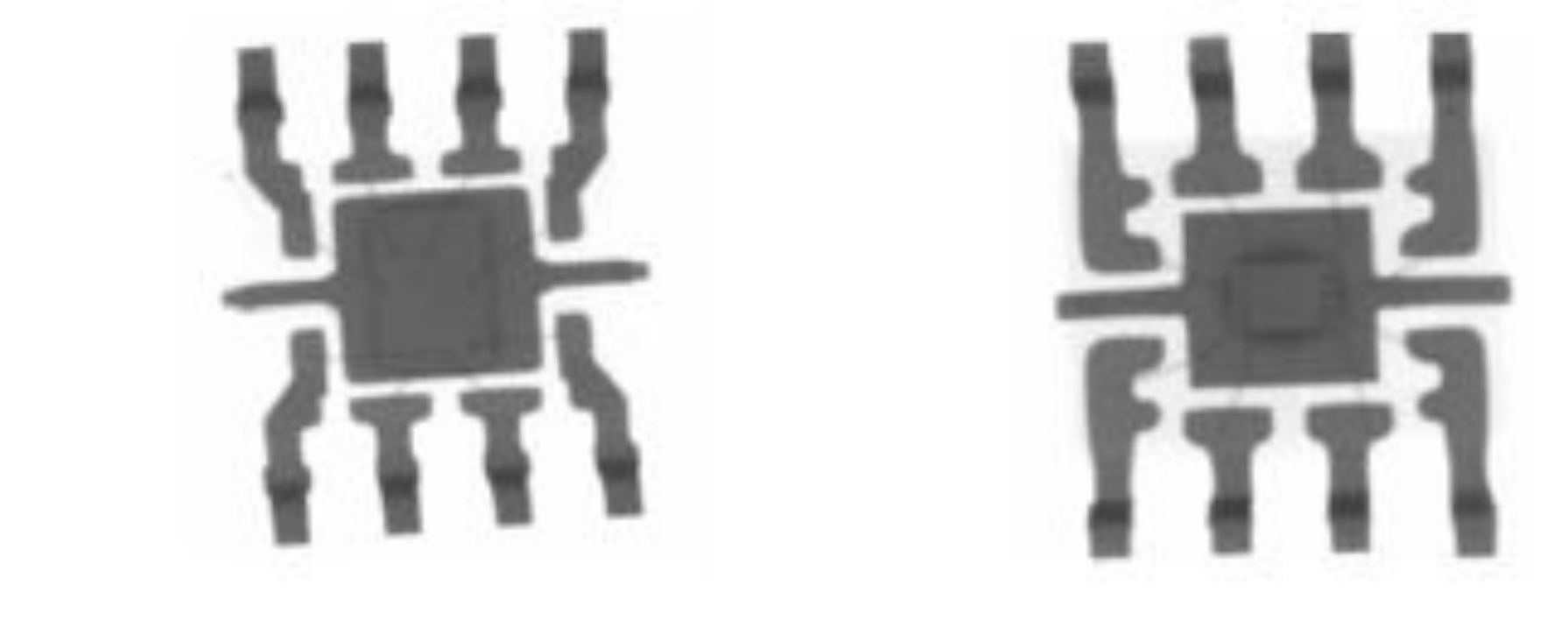


- On a reel, 10% of Samsung 128kx8 CMOS static RAM ICs were like the x-ray on the left. The balance were like the x-ray on the right.
- Over-coating was present - pin 1 dimple covered with blacktop.
- Suspect part – Mixed construction. Die shrink. May have been remarked by OCM; should be verified.
- Wiring in x-ray correlates with Samsung pin-out drawing.
- Should be functionally tested for speed.

Courtesy Creative Electron

Counterfeit Examples

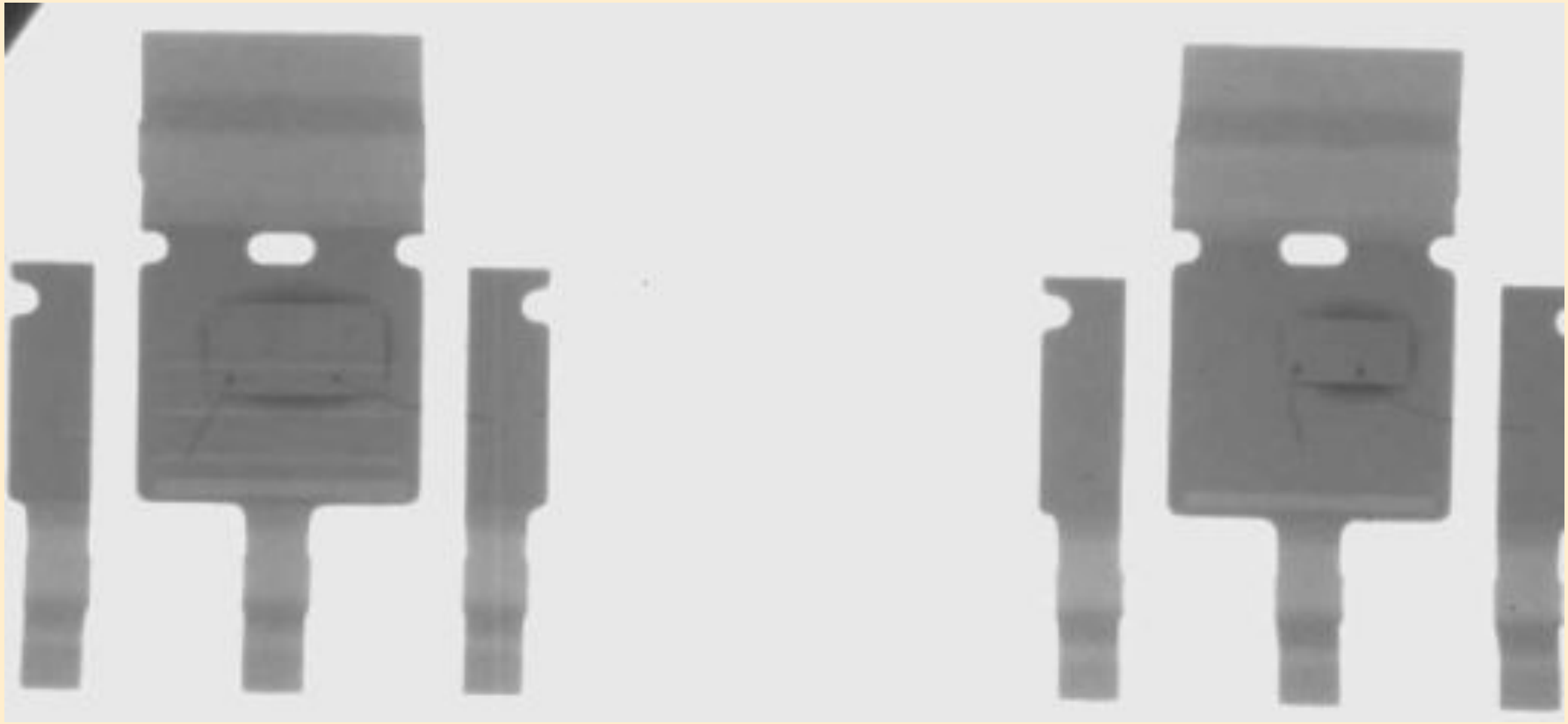
X-Ray Analysis



Same part number and date code but different die.
Sample inspection is not valid due to different construction.

Counterfeit Examples

X-Ray Analysis



Same part number and date code but different die.
Sample inspection is not valid due to different construction.

Counterfeit Examples

X-Ray Analysis Conclusion

- X-ray is important to assure consistent internal construction for sample inspection:
  - Decap and die inspection
  - XRF test of leads
  - Solderability test
- Quick determination of uniform internal characteristics to save investing more costs and time to determine components are counterfeit.
- Comparative Analysis important– must be able to spot differences
- This testing can be performed in-house or by a contractor.
- Requires experienced personnel to make & read X-rays.
- The X-ray must have proper exposure to show important details.

Most manufacturers reserve the right to make changes in design and materials without providing notification, but usually have different date codes.

Counterfeit Examples

Die Verification:

- Characteristics to look for on die;
- Examples of the various markings and their significance;
- Photographing die marking;
- There is not way the counterfeiter can alter die markings
- Die can be harvested and repackaged.
- Authentication of the component with die markings:
  - Very difficult
  - When not obvious, OCM assistance is needed.
  - Few will assist unless procurement traceable to them

Counterfeit Examples

IC Die Markings

- There is no industry standard that requires the OCM to mark the die the same as the exterior part number on the package.
- Die may yield several variations of part numbers by sorting at wafer testing, i.e. temperature range, speed, etc.
- The die may, or may not, be marked with a mask number, the part number, a company logo, a date, trademark symbol, or anything the OCM chooses, *or nothing at all*.
- When the mark on the die is not the part number, but a code it must be decoded to prove authenticity, typically with OCM assistance.
- Even if it has the correct OCM logo, it may not be the right die for the P/N.
- All markings must be photographed and recorded for CCAP-101 Certified orders.

Counterfeit Examples

Die Authentication

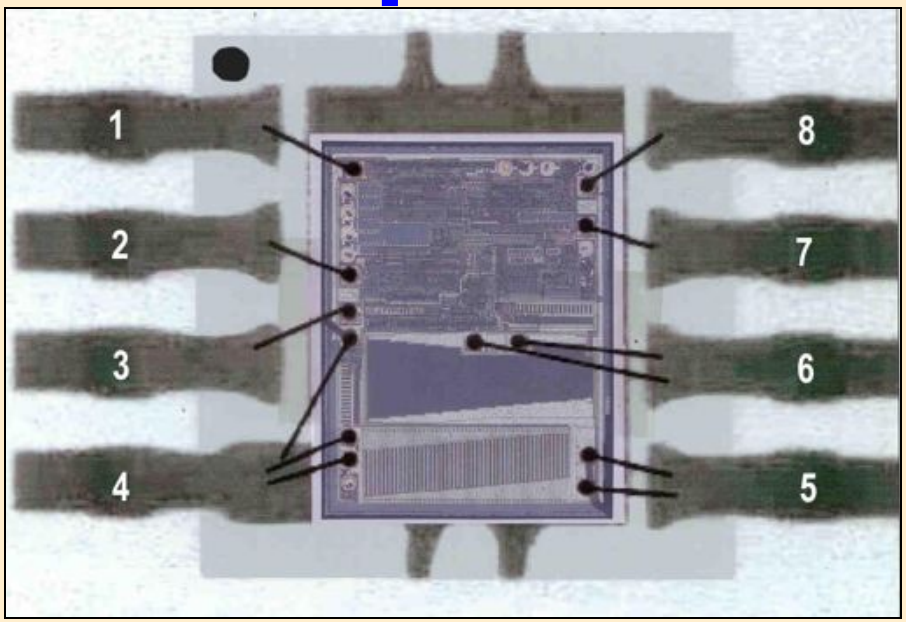
Examples of die that have no logo or P/N on die

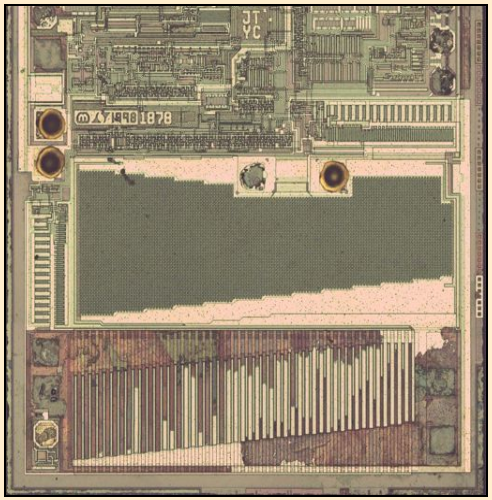
- Zener diodes
- Rectifier and signal diodes
- SCR's
- Power modules
- Many older and obsolete components.
- Discretes and ICs with small dice such as switching, small signal, RF in the SOT package, etc. a logo takes up too much silicon "real estate".

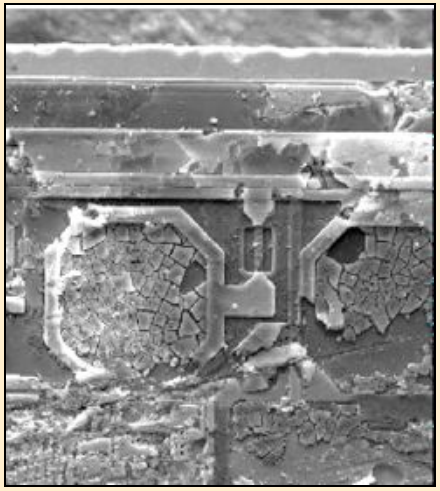
Counterfeit Examples

CHEMICAL ATTACK

- LTC 1878 device purchased from broker.
- Sudden 10% yield problem at FT, 90% yield normally runs 99+%.
- Curve trace of pins showed open pins, many multiple, on each device.
- Optical photos show corroded and missing metallization.
- De-cap and SEM shows badly attacked Al metal.
- Wrong acid used to strip plating; likely dilute HCl instead of H_2O_2
- Acid penetrated the package and etched Al from the pad windows.
- Photo is a composite of images.
- XRF spectrum of lead shows only Sn and Cu, data book shows Pb-Sn.





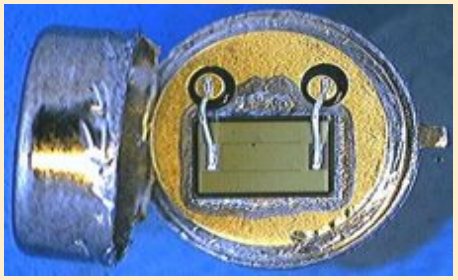


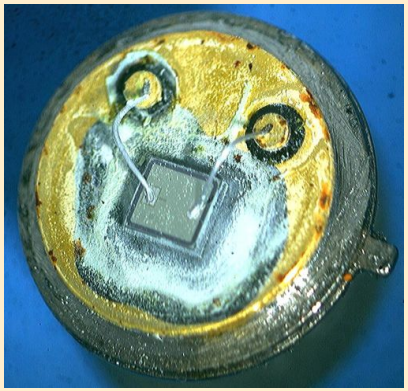
© Thomas Lee

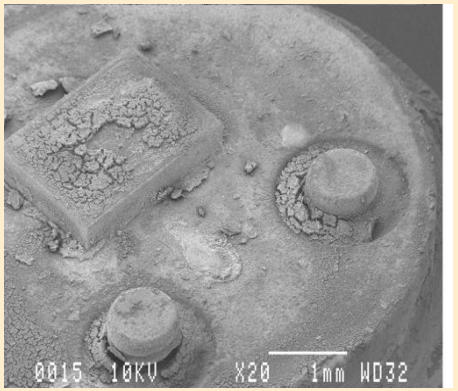
Counterfeit Examples

JAN TX Counterfeit

- MIL / AERO field failure
- Obsolete. Purchased from broker. Unavailable from licensed re-manufacturers.
- Marking on D/C 0326 parts was amateurish, poor quality and illogical. No Harris or Intersil mil-grade parts made since 1999.
- Marking on D/C 9915 was good. One part out of 75 was sampled because of high unit cost.
- De-cap and internal visual showed no problems, but die too big should be 62x62.
- Markings on failed parts removed by acetone.
- All parts opened from failures had 3 different die sizes.
- Parts has Pb-Sn solder die bonds. Harris/ Intersil used only Au die bonds.
- Interior of parts was coated with PbO. Al wire bonds were corroded away and open.
- Parts are counterfeit and poorly manufactured.







© Thomas Lee

Counterfeit Examples

Die Authentication

- Package markings were altered to ADSP-2100. Package date code was not recorded.
- Dice inside two example parts found to have correct OCM logos, but different mask numbers and dates.
- Legitimacy of these mask numbers for an ADSP-2100 P/N and package date code was apparently not researched.
- However, altered markings rendered the part counterfeit, and analysis coul have stopped with only the visual inspection.
- Particles on surface of dice should have been removed with proper cleaning techniques after decap.

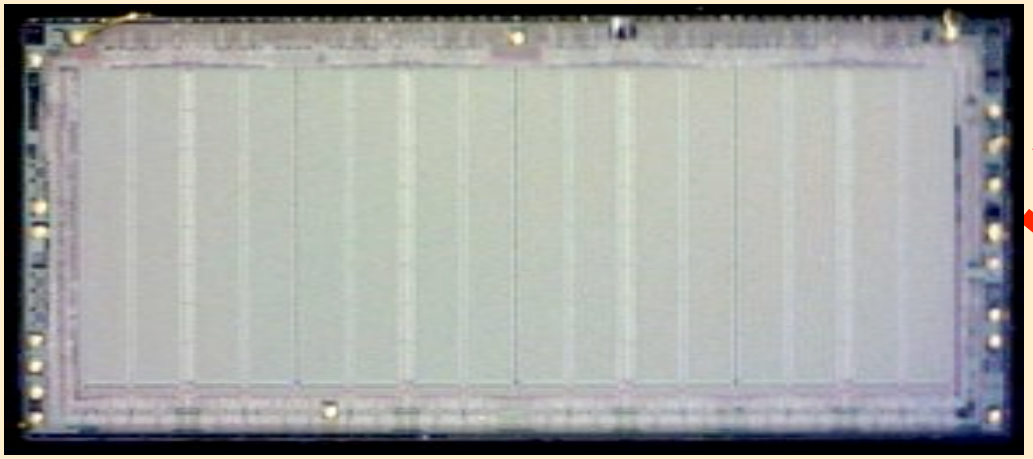
Copyright Thomas Lee

Counterfeit Examples

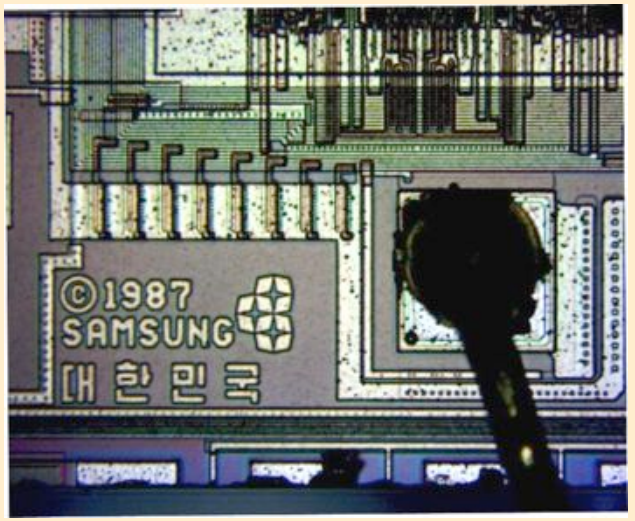
Die Authentication

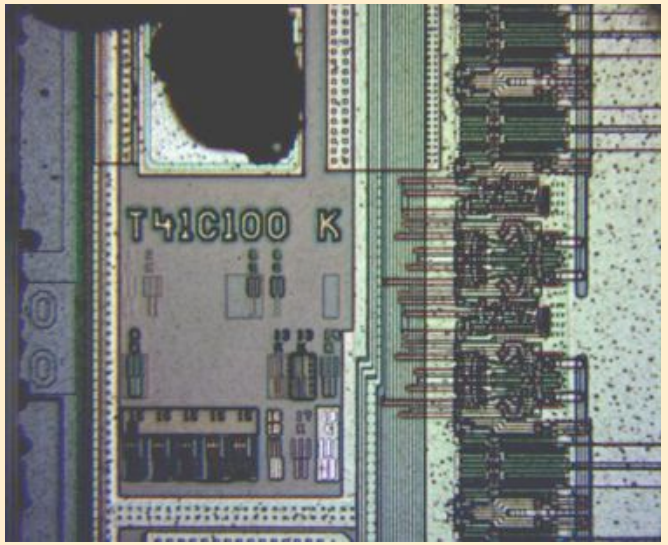
Samsung KM41C10008P-8 4MB CMOS DRAM.

- Die photos of DRAM and SRAM dice are difficult to make.
- Low-power shots cannot show logo at the magnification necessary to fit the entire die into one photo
- Arrows should be used to show locations of die marks.
- This shows date of mask, not package date code.
- Samsung logo and mask/part number show that die is authentic to P/N.



Full-die photo with location indicators





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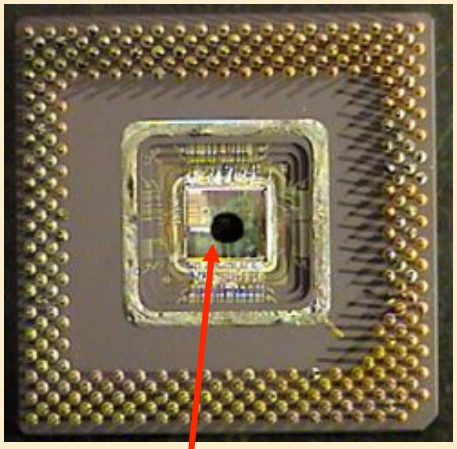
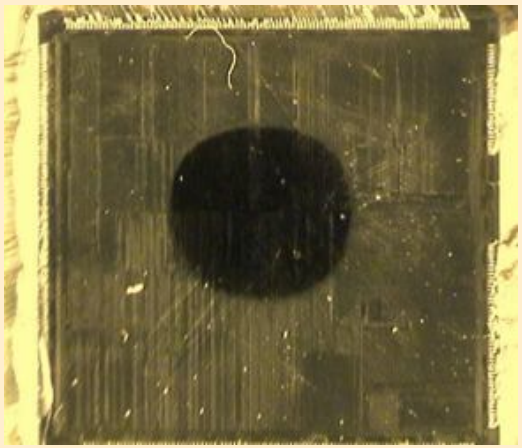
Counterfeit Examples



Looks simple enough Intel device, marking not too bad, but LOOK,

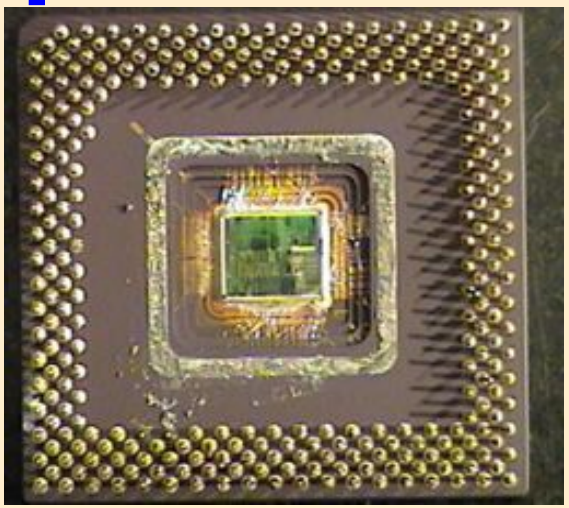


The ink dot that identifies a reject from wafer sort.

Here is the chip ID found after decap, looks good and matches the package marking

Courtesy & Copyright Custom Analytical Services

Counterfeit Examples



Same lot, same numbers but there is no ink dot

The characters are backwards, indicates the whole wafer & all die were rejects.

Courtesy & Copyright Custom Analytical Services

Counterfeit Examples

5962-8771501CX ; Dual Op-Amp, *May 2012*

Customer:

- Requested RCA of failed devices
- Known good & failed devices provided

Follow on Analysis

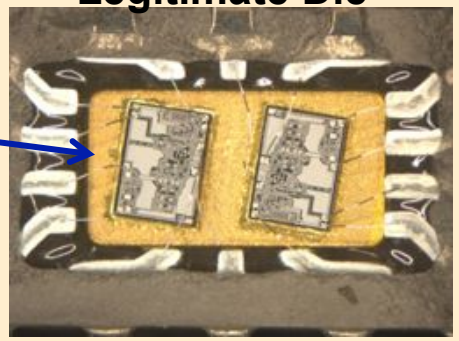
- Marking Differences noted
- X-ray & Optical Die differences noted
- Multiple Die Inside!
- Linear Tech Confirmed these were counterfeit

ISSUES:

- As a contractor, we are required to report BUT is out of scope & not covered (yet) in commercial contract Terms & conditions
- Many long lead components (previous slide) acquired PRIOR to NDAA 2012

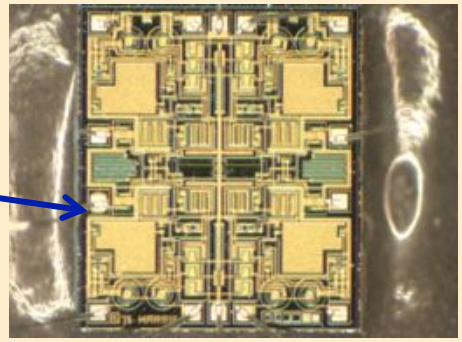
Legitimate Markings

Legitimate Die



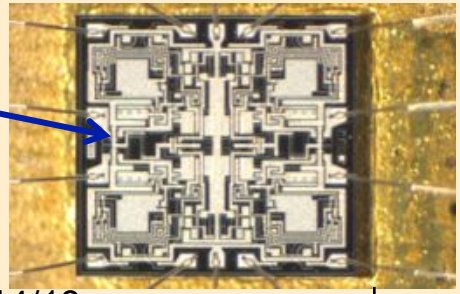
Suspect Markings

Harris Die!



Suspect Markings

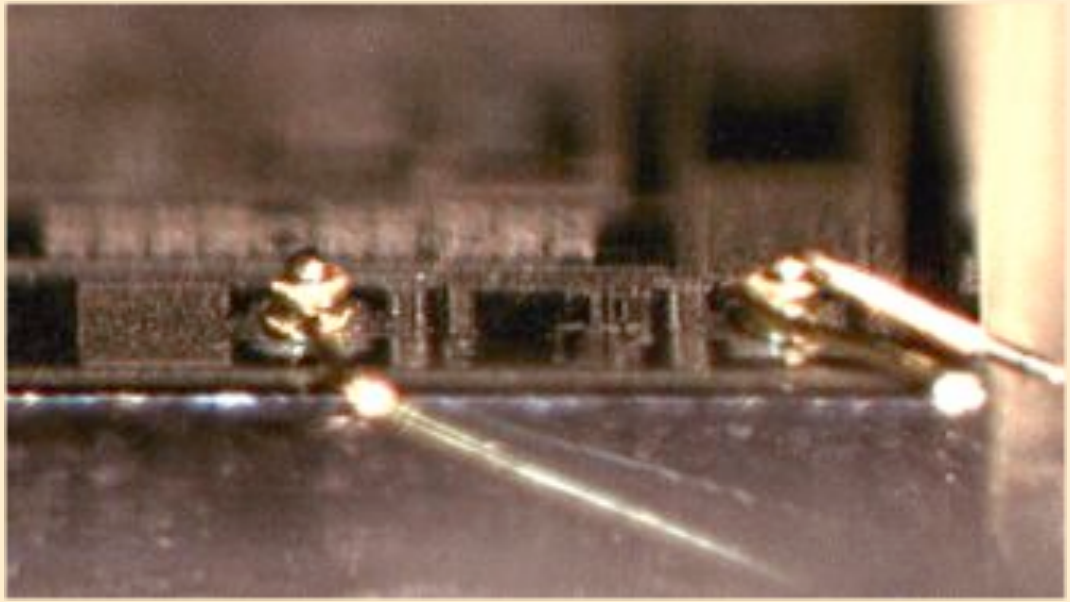
Who's Die??



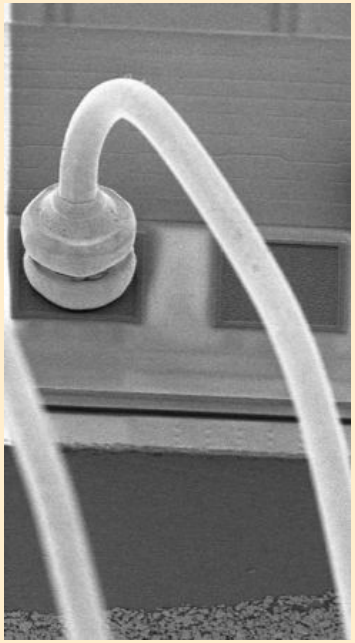
Courtesy Aaron DerMarderosian, Raytheon Corp.

Counterfeit Examples

Manufactured Counterfeits - **Major new threat**



Actual bond on bond
Search for this after decapping.
Note the angle required for side view.



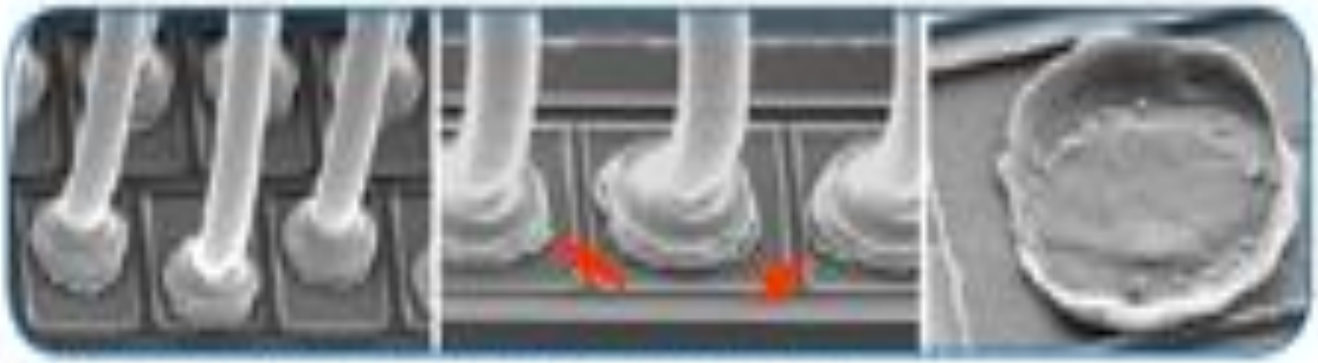
This is how new bond on top of original bond looks with SEM.
A NEW MANUFACTURED COUNTERFEIT

Counterfeit Examples

Die Authentication

Considerations for Cu Wire Bond

- Larger bond pad opening (BPO) is recommended
  - Minimum 4um larger than for same diameter Au wire
  - Cu wire has greater tendency to "splash" out due to higher bond force



- Cu wire bond success is highly dependent on silicon structure
- Amkor has compiled engineering data on many bond pad structures – Not easy to generalize

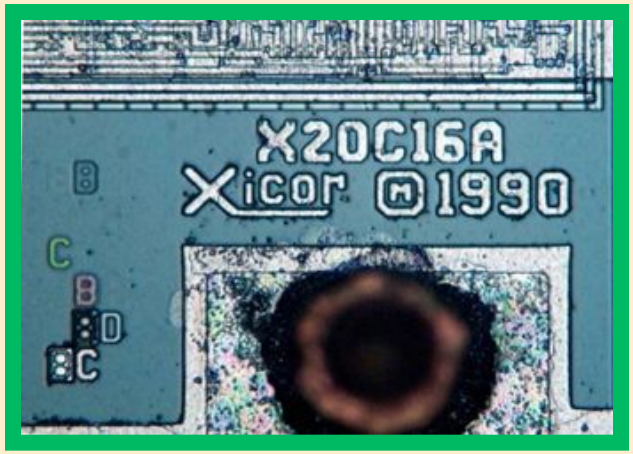
Texas Instruments started Cu wire bonds in 2008, last year had shipped 6.5 billion units.

Courtesy Amkor

Counterfeit Examples

Die Authentication – Die marks

- When the marking on the die matches the marking on the package the part is authentic but may still be remarked or reclaimed.
- When the marking on the die does NOT match the package marking (right), the part may be counterfeit or authentic, depending on what the OCMs uses for die mark.
- A correct OCM logo match with P/N is a good start.
- Without this, lengthy and difficult research is required to prove authenticity.
- Procurement acceptance time should allow for this investigation.



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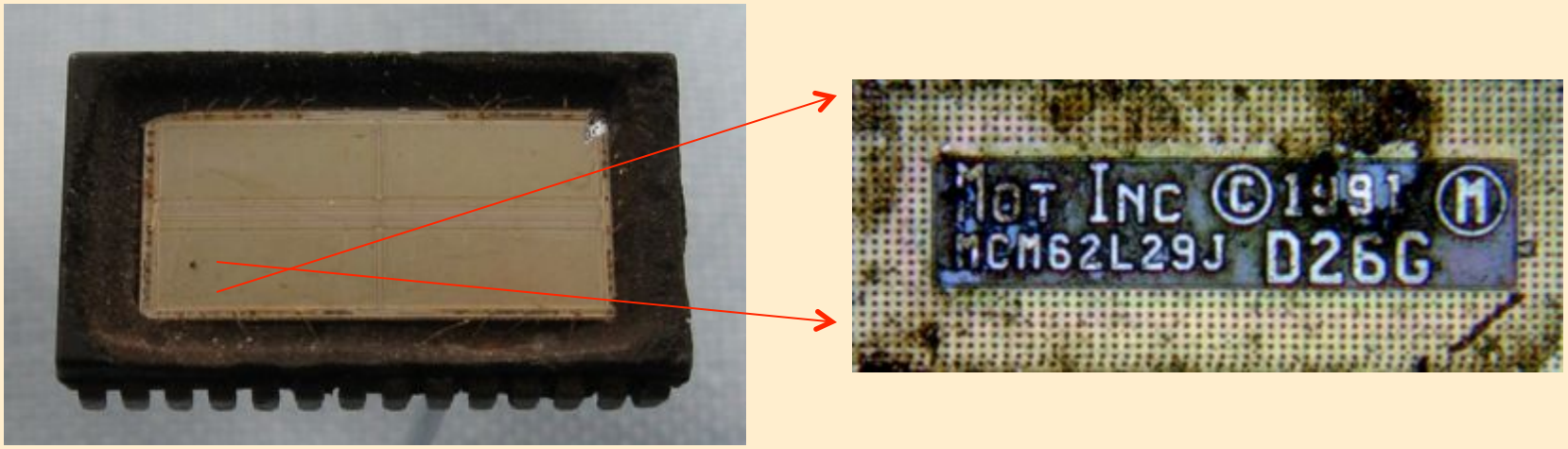
Counterfeit Examples

Die Authentication – Memory die



MEMORY DIE are extremely difficult to inspect and photograph due to their high aspect ratio. Most microscopes have a minimum magnification of 10x. The magnification required for a memory chip photo is about 1x because of the chip length.

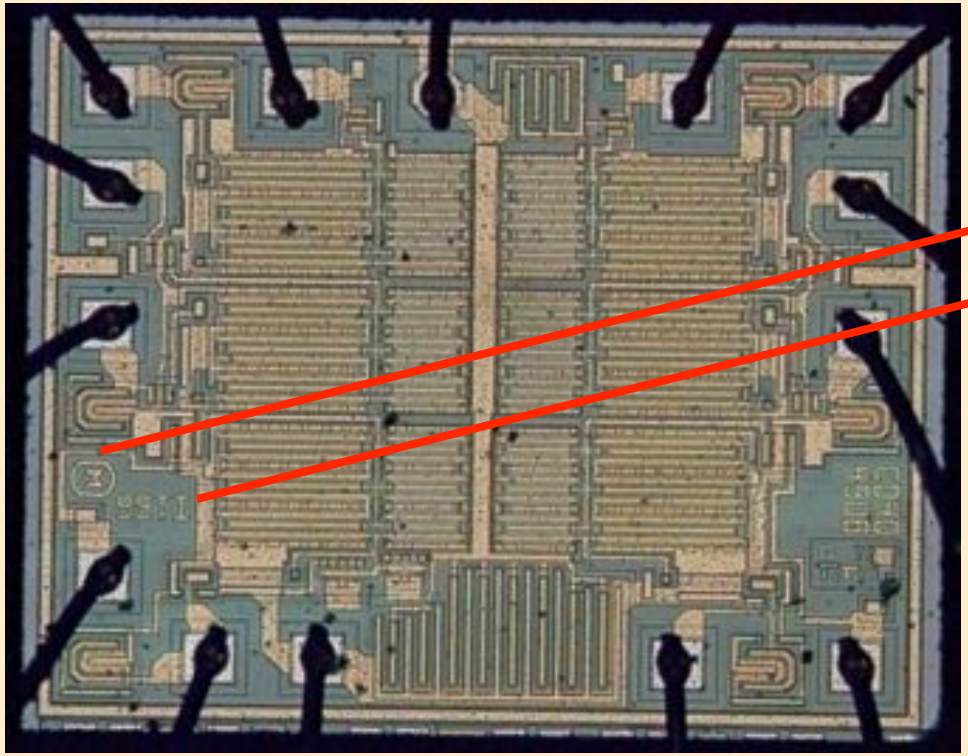
Photographs of the memory die markings typically require hi mag. but are important records.

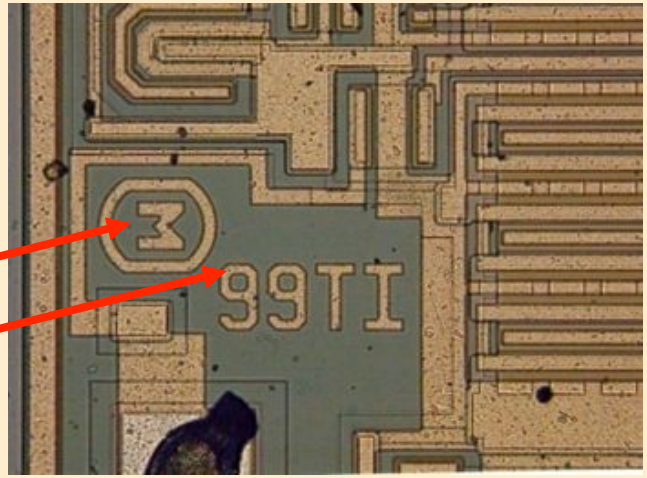
Copyright Thomas Lee

Counterfeit Examples

Die Authentication – Die markings

Die photos should include full-die photo showing location of markings and a high-power one to show trademark, date and mask ID, if present. (Note "M" means "trademark", not "Motorola".)





Detail high-power photo

Full-die photo with location indicators

Copyright Thomas Lee

Counterfeit Examples

Complexities of authenticating die photos

- **Die size**
  - IC die may be "shrunk" for increased yield; sometimes more than once.
  - Die design may be cross-licensed among several OCMs
- **Die logos**
  - Some older die never had either logos or mask numbers
  - Die designs may be cross-licensed; logo on package and on die can be different.
- **Dates** – Date of die mask completion or copyright registration
- **Mask Numbers**
  - May have no obvious relation to part number and are often revised.
  - May have to be decoded by manufacturer.
  - Speed and Temperature not normally representative by die mask number, determined at test.
  - Alignment keys are not suitable for identification
- **Device Numbers**
  - Do not necessarily appear on die, if may be a product line number.
  - Chip manufacturers appear and disappear, become acquired, change names, locations, etc.
- **Die layout**
  - Only major functional blocks are visible
  - Part can have several versions with different layouts
  - Cross-licensed part can have different layouts

Detailed knowledge required to verify some older products and may be entirely lost or require ambitious searches.

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Counterfeit Examples

Correlating die marks to P/N.

- IC manufacturers do not in general assist independent distributors in establishing authenticity.
- Some IC OCMs provide a verbal response about authenticity of a die in a photo - it is a rare courtesy to some OEM customers. Most want purchase traceability to them or AD.
- Military OCMs may provide die photos, but usually only in conjunction with a sizeable order or a special customer.
- It is expensive for OCMs to research and supply obsolete component die verification data and may have legal ramifications.

Counterfeit Examples

Die Authentication - Conclusions

- The assessment accuracy and completeness of die marks depend primarily on the manufacturer's data sheet information and the cooperation and knowledge of the manufacturers' representatives.
- Devices are made and molded by a batch process, then tested, classified and front-side marked at two different times, separated by months, or even years.
- Manufacturers may cross-license products and die designs, resulting in different manufacturer's marks on the package exterior and internal silicon die.
- Some manufacturers use contract houses to package, mark and test their devices.
- Sometimes the quality and workmanship on authentic devices may vary, and be substandard.

Counterfeit Examples

CONCLUSION

- Thorough external visual inspection can detect a high percentage of counterfeit components, inexpensively.
- Remarked, altered marking & reclaims are counterfeits.
- Marking permanence testing can reveal many remarks.
- Scrape & HST can remove blacktopping and reveal sanding, and possible original markings..
- Lead conditions and ends can reveal reclaimed and refurbished components, beware of fake copper appearance - which are counterfeit.
- Counterfeiters have greatly improved in hiding their work and it is much more difficult to detect them.
- Detection of counterfeits requires great investigative instincts.
- Suspect and counterfeit components cannot be Certified as CCAP-101.

Counterfeit Examples

Identifying Counterfeit Passives

- **Visual Inspection**
  - Wrong package color
  - Dull surface finish with rounded edges
  - Not OCM packaging
  - Physical dimensions
- **Electrical** - Very important for passives
  - ESR outside of specification limits
  - Primary parameters should be tested
  - Rating tolerance, TC,
- **X-Ray**- Electrolytics – Ta & Al
- **DPA** (Destructive Physical Analysis)
  - MnO2 Cathode vs Polymer Cathode - Ta
  - Wrong terminal material or dielectric thickness MLCC
  - Other attributes

Counterfeit Examples

Manufactured Fakes

- Capacitance measurement
- X-ray
- Decap

Counterfeit Examples

Tantalum Counterfeit

Commercial Series repackaged as Low ESR/Multiple Anode Series

Counterfeit

Authentic

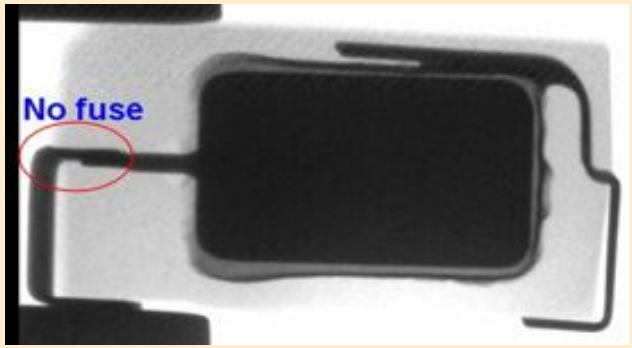
Courtesy Kemet

Counterfeit Examples

Kemet Counterfeit

Standard series repackaged as a Built-in Fuse Series

Counterfeit



Authentic

Courtesy Kemet

Counterfeit Examples

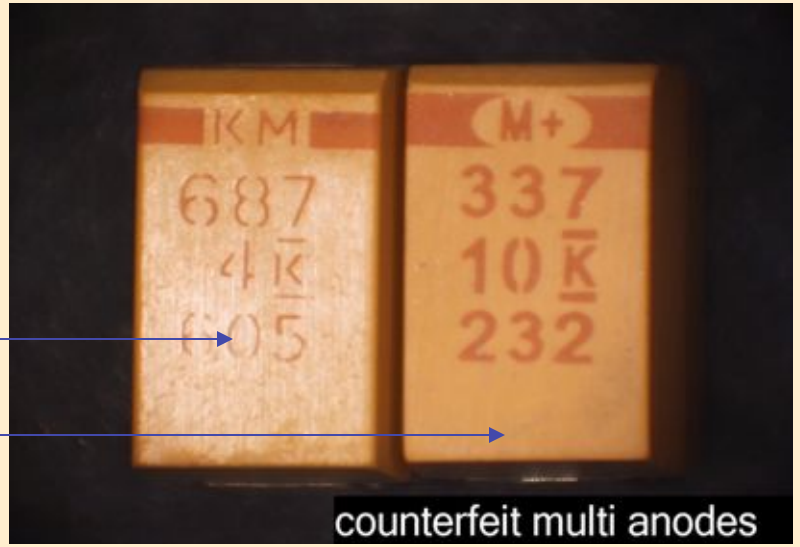
Inspection of the Print Face

Light Reflection Test

- Counterfeiters must remove the print.
- Once the print face is removed, the component surface will not reflect light.

Passes Light Reflection Test

Fails Light Reflection Test

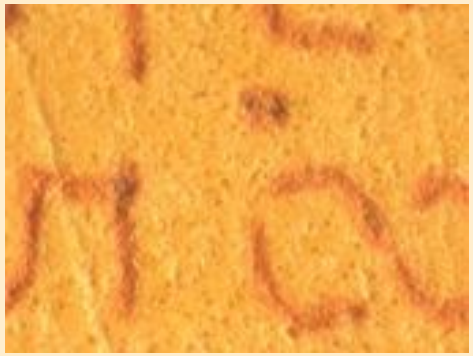


Courtesy Kemet

Counterfeit Examples

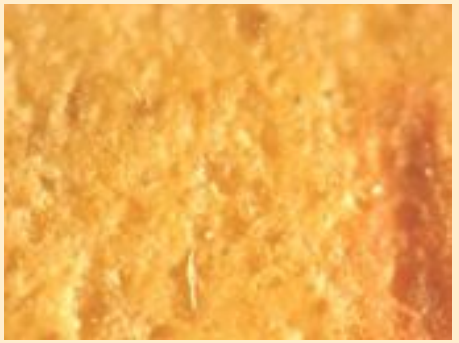
Inspection of the Print Face (*Cont.*)

Epoxy case magnification: Counterfeit.



50X

100X



200X

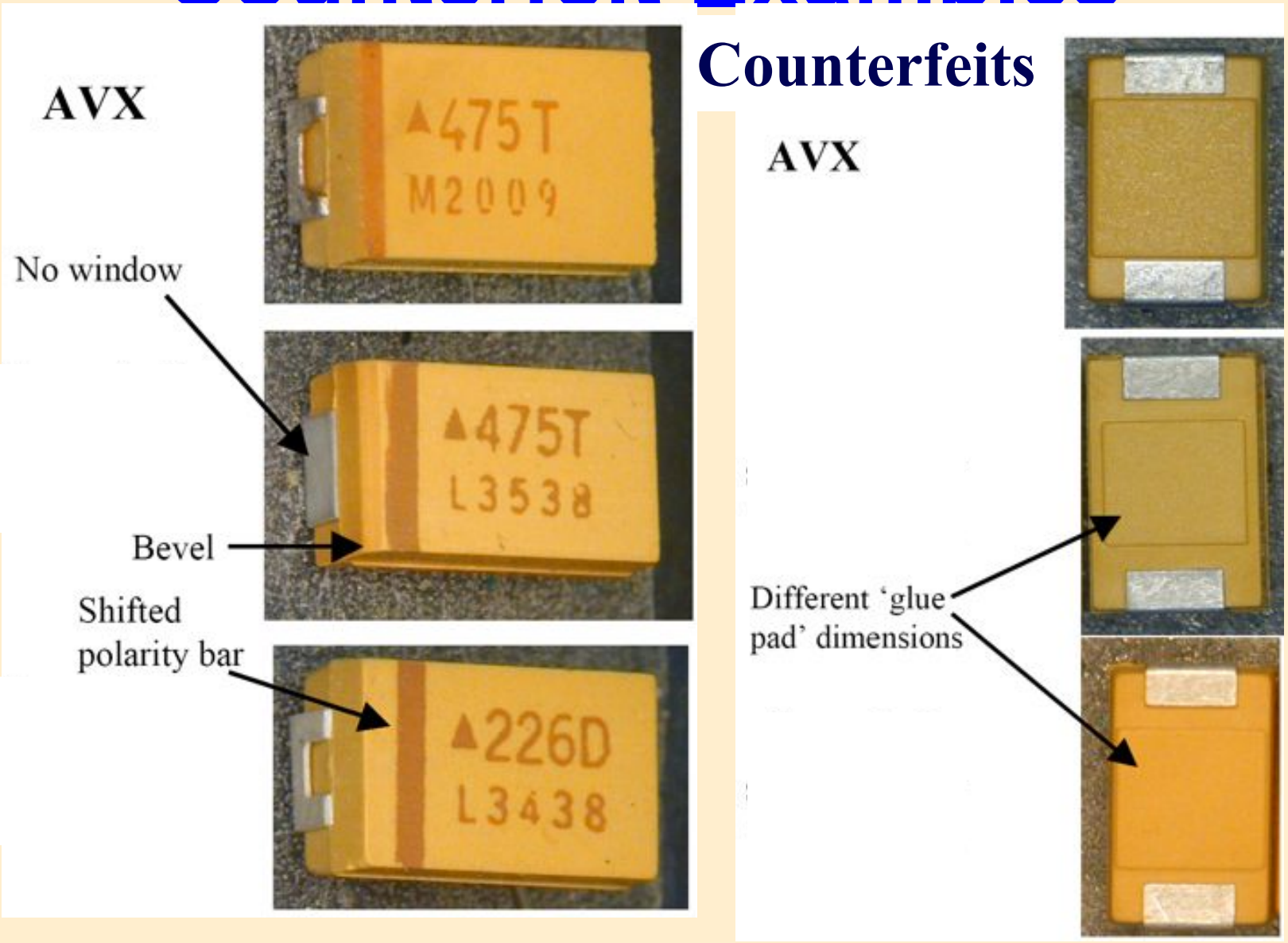
Epoxy case magnification: Authentic

50X

100X

200X

Counterfeit Examples



Couresy AVX

Counterfeit Examples

Counterfeit Resistors

Resistors are being counterfeited primarily by:

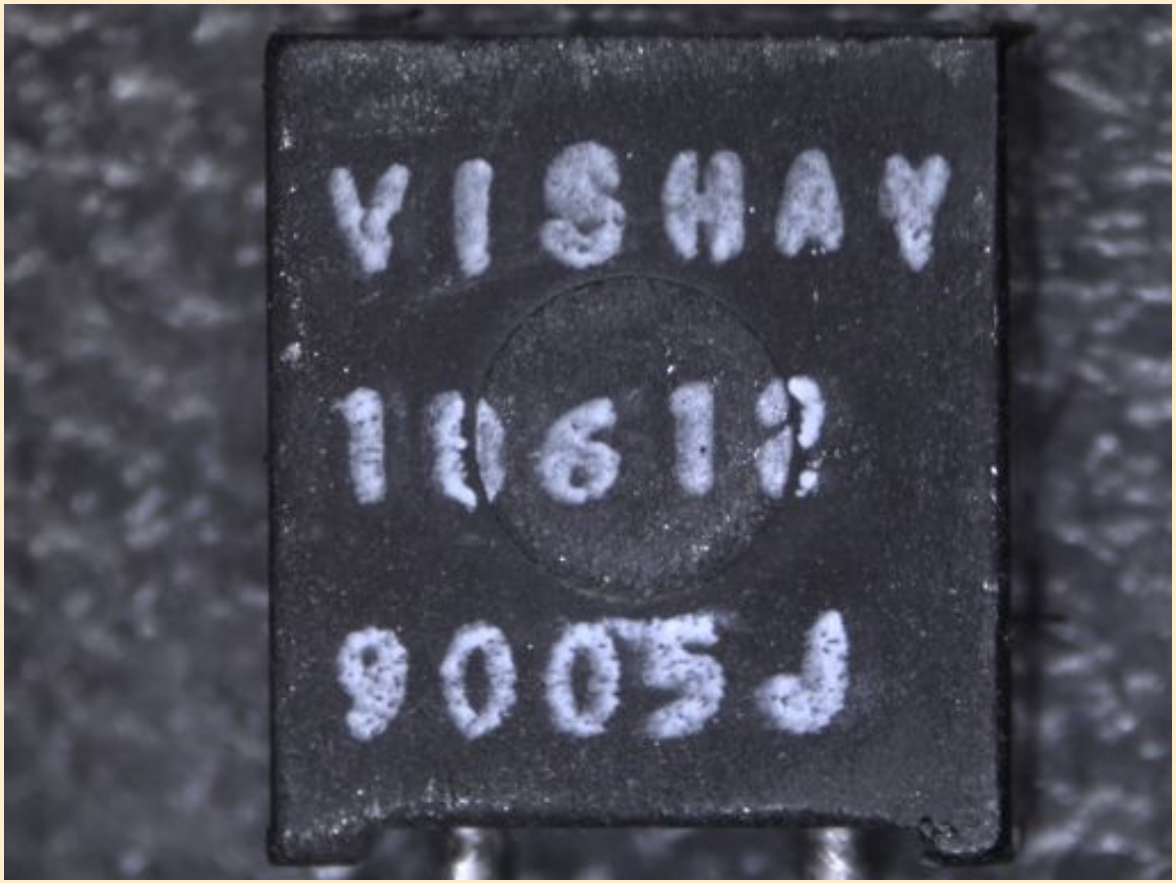
1. Reclaimed from scrap electronics and sell as new.
2. Switch-a-roo, lower TC, lower accuracy, lower quality for higher performance and price resistors.
3. Salting the fake resistors with a few of the authentic ones, to be found by the customer and think they are all authentic.

Detection requires:

- dimensional checks
- increased sampling for visual and electrical
- electrical test of key parameters over temperature.
- is the packaging typical for the OCM named.

Counterfeit Examples

Vishay Metal Foil Resistor RNC90Y2K0000FR



Counterfeit Examples

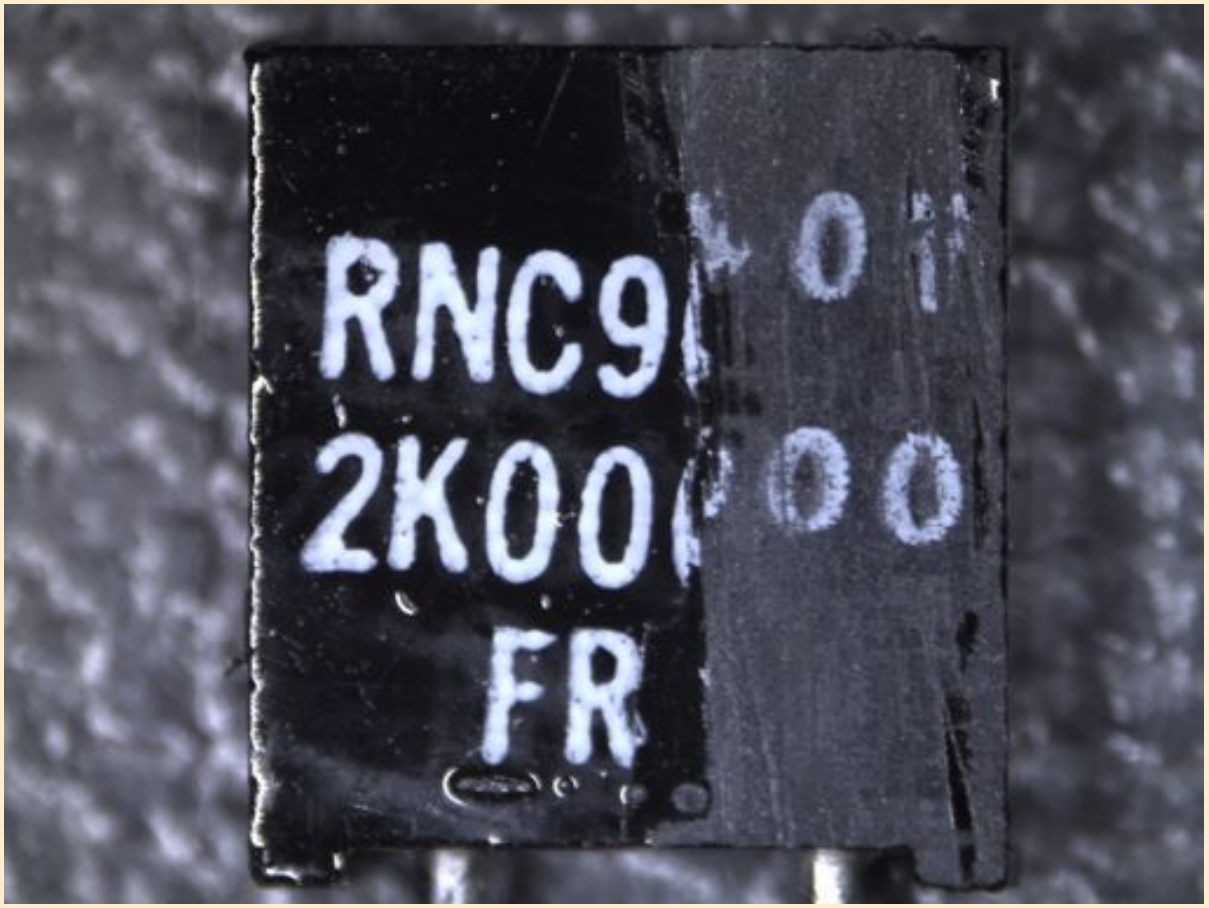
Blacktopped Vishay Resistor

Counterfeit Examples

Acetone Test

Authentic samples available from Vishay.

Leads should show signs of previous use.



Counterfeit Examples

See original markings

Shows scratches from removal of epoxy markings

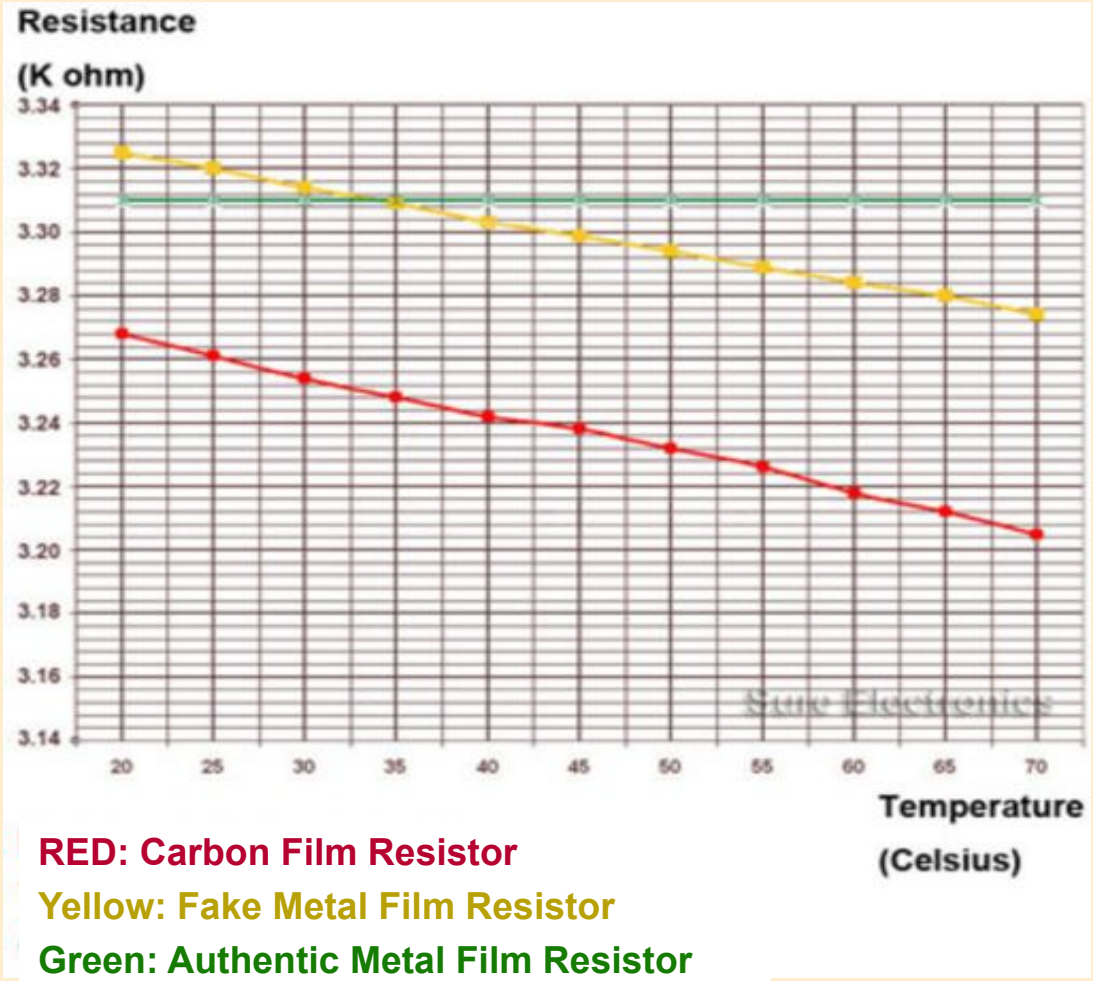
Counterfeit Examples

Fake Metal Film

Carbon film resistors are repainted in order to look like metal films.

Electrical test over temperature is required to verify performance.

Resistance vs Temperature



Counterfeit Examples

Electrical Tests for Passives

All passive components not contained in OCM verified packaging should be sample tested, 50 pcs/1000 minimum as specified below per data sheet or mil spec. Most passives can be tested with electronic bridges, DWV testers and curve tracers.

Capacitors:

Capacitance & tolerance 25 ^{0}C and min/max temp

Leakage current

ESR (Electrolytics)

Inductors:

Inductance over or within specified frequency and temperature range

Q

Series resistance

Resistors:

Resistance and tolerance at 25 ^{0}C and min/max temp

Temperature coefficient

Counterfeit Examples

Identifying Counterfeit Passives

Summary

- Reference the OCMs unique component marking.
  - Ensure that the format meets the suppliers documentation & data sheet.
- Keep examples of known good product on hand.
  - Look for differences in label format.
  - Compare the font, ink vs laser, dimensional check, etc.
  - Most OCMs supply sample kits of passives.
- The OCM may provide conformation of reel information.
  - The manufacturer can verify if the labeling information is correct.
- Counterfeit and Suspect components cannot be shipped to CCAP-101.
- **Destroy counterfeit components. If you don't, they will return to the supply chain.**